FINAL DRAFT SAMPLING AND ANALYSIS ADDENDUM
CHEMICAL FATE AND TRANSPORT MODELING STUDY
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

Prepared by

Anchor QEA, LLC

614 Magnolia Avenue

Ocean Springs, Mississippi 39564

September 2010

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LIST OF ACRONYMS AND ABBREVIATIONS

ADCP	Acoustic Doppler Current Profiler
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
COPCs	contaminants of potential concern
CSMs	conceptual site models
CTD	conductivity, temperature and depth
DQOs	data quality objectives
EFDC	Environmental Fluid Dynamics Code
FS	Feasibility Study
GSD	grain size distribution
I-10	Interstate Highway 10
IPC	International Paper Company
MIMC	McGinnes Industrial Maintenance Corporation
mm	millimeter
NPL	National Priorities List
QAPP	Quality Assurance Project Plan
QEAFATE	chemical fate and transport model
RI/FS	Remedial Investigation/Feasibility Study
ROD	record of decision
SAP	Sampling and Analysis Plan
SEI	Sea Engineering, Inc.
SJRWP	San Jacinto River Waste Pits
TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended sediment
UAO	Unilateral Administrative Order
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geologic Survey

1 INTRODUCTION

This Sampling and Analysis Plan (SAP) Addendum to support a chemical fate and transport modeling study of the San Jacinto River was prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC; collectively referred to as the Respondents). Previously, the Respondents have submitted the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (Anchor QEA and Integral 2010) in fulfillment of the 2009 Unilateral Administrative Order (UAO). The UAO, Docket No. 06-03-10, which was issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009, (USEPA 2009) directs the Respondents to prepare an RI/FS Work Plan for the San Jacinto River Waste Pits (SJRWP) Site in Harris County, Texas (the Site). This SAP Addendum was created to supplement the submitted RI/FS Work Plan by describing the modeling efforts to be undertaken in support of achieving the overall RI/FS goals.

1.1 Purpose

On March 19, 2008, USEPA added the Site to the National Priorities List (NPL), and the 2009 UAO requires that an RI/FS be conducted at the Site. The RI/FS will be undertaken to address the following objectives:

- Characterize the nature and extent of Site-related contamination
- Perform a baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA)
- Evaluate the physical characteristics of the Site and physical processes governing fate and transport of Site-related contaminants
- Develop and evaluate potential remedial alternatives for the Site

A comprehensive description of the work to be performed, the methods to be used, and the schedule of activities that will address these objectives was presented in the submitted RI/FS Work Plan and expanded upon in the SAP (for sediment-related activities). Once complete, a remedy will be chosen and USEPA will document final selection of the remedy in a record of decision (ROD).

Conducting a chemical fate and transport modeling study will produce management tools that can be used to reliably investigate current and future conditions in the Study Area. The development of hydrodynamic, sediment transport and chemical fate and transport models will make it possible to understand how chemicals are transported throughout the Study Area, as well as the ultimate fate of these chemicals. Results of the chemical fate and transport model are anticipated to include predictions of spatial distributions and temporal variations of chemical concentrations in the water column and sediment bed. In addition, the models can be used to quantitatively evaluate the effectiveness of potential remedial actions.

1.2 Work Plan Organization

Section 1 of this SAP Addendum presents an introduction and brief overview of the project while Section 2 describes the problem addressed by this Work Plan. The modeling framework and approach is presented in Section 3. Data gaps and data quality objectives (DQOs) for the modeling study are described in Section 4. Field studies to be conducted in support of the modeling analyses are presented in Section 5. The schedule for the modeling study is presented in Section 6.

2 PROBLEM DEFINITION

2.1 Site History

Detailed Site history information was provided previously in the RI/FS Work Plan and SAP and is summarized here, within the context of the work scope of this Addendum. The Source Area component of the Site consists primarily of a set of impoundments that were approximately 14 acres in size and were built during the 1960s for containment and storage of paper mill wastes. In addition, a portion of the Site (i.e., area surrounding the Source Area) contains sediments and soils potentially contaminated with the waste materials that had been stored in the impoundments. The impoundments are located on a 20-acre parcel along the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge that passes over the San Jacinto River (Figure 1). The preliminary Site boundary in the 2009 UAO defines an area of 814 acres surrounding the waste impoundments. For the purposes of the modeling study, the Study Area is defined as the San Jacinto River from Lake Houston to the Houston Ship Channel (Figure 1).

In 1965 and 1966, pulp and paper mill wastes (both solid and liquid) were transported by barge from the Champion Papers Inc. paper mill in Pasadena, Texas and unloaded at the Site into the waste impoundments. In a letter dated July 1966, the Texas Water Pollution Control Board stated that it was their understanding that no additional waste material would be placed in the impoundments.

Physical changes at the Site in the 1970s, 1980s, and 1990s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the impoundments and exposure of the contents of the impoundments to surface waters. Based upon review of the U.S. Army Corps of Engineers (USACE) approved dredging permits, dredging by third parties has occurred in the vicinity of the impoundments. Recent samples of sediment in nearby waters north and west of the impoundments (University of Houston and Parsons 2006) indicate that dioxins and furans are present in nearby sediments at levels higher than levels in background areas nationally (USEPA 2000).

The impoundments are currently occupied by estuarine riparian vegetation to the west of the central berm, and are consistently submerged even at low tide to the east of the central berm. Estuarine riparian vegetation lines the upland area that runs parallel to I-10 and west of the impoundments. A sandy inter-tidal zone is present along the shoreline throughout much of the Site.

2.2 Statement of the Problem

An analysis of chemical fate and transport processes in the Study Area is needed to perform the evaluation of remedial alternatives during the Feasibility Study (FS). Evaluating the effectiveness of various remedial alternatives requires the development of qualitative and quantitative methods to analyze the fate and transport of particle-associated chemicals within the Site and Study Area (Figure 1; based on the extents shown in Figure 3 from the RI/FS Work Plan). The FS will require evaluations of: 1) the extent of potential impacts of materials deposited in the waste impoundments; 2) the feasibility of various remedial actions; and 3) the current and likely future sediment conditions within the Site.

2.3 Primary Objectives of Modeling Study

The main goal of the work discussed in this SAP Addendum is to simulate physical and chemical processes that are controlling chemical fate and transport of key Site-related contaminants within the Study Area. Besides the usefulness of the modeling analyses presented in this SAP Addendum for remedial investigation purposes, there is an associated goal of developing a predictive model that can be used to evaluate the efficacy of various remedial alternatives under a variety of flow regimes and time frames.

The evaluation of chemical fate and transport within the Study Area will use a combination of data (empirical) and modeling analyses. The primary objectives of the chemical fate and transport analysis are: 1) develop conceptual site models (CSMs) for sediment transport and chemical fate and transport; 2) develop and apply quantitative methods (i.e., computer models) that can be used as a management tool to evaluate the effectiveness of various remedial alternatives; and 3) answer specific questions about sediment transport and chemical fate and transport processes within the Study Area.

The hydrodynamic model will be used to establish the basis of riverine transport processes presented in the physical CSM, and to support the sediment transport and chemical fate and transport models. The hydrodynamic model will provide insight into specific hydrodynamic processes in the Study Area.

The sediment transport model will be used to address these questions related to long-term, multi-year periods:

- What areas in the Study Area are net depositional, net erosional, or in dynamic equilibrium?
- What is the net sedimentation rate in areas that are net depositional?
- What is the potential depth of scour during high-flow events or storms in areas that are net depositional, net erosional, or in dynamic equilibrium?
- What is the fate of sediment eroded from the waste impoundment area?

This model will also be used to answer questions related to episodic high-flow events in the San Jacinto River and storms (e.g., hurricanes):

- What areas are depositional and what areas experience erosion during a high-flow event or storm?
- In the areas that experience erosion during high-flow events or storms, what is the potential depth of scour?
- What is the potential for re-exposing buried sediments?

The chemical fate and transport model will be used to answer these questions:

- What is the fate of particle-associated chemicals that are remobilized from the waste impoundment area under current conditions?
- What is the rate of natural attenuation of chemical concentrations in the surface-layer of the sediment bed in locations that may be impacted by releases from the waste impoundment?
- What are the effects of high-flow events or storms on chemical concentrations in the surface-layer of the sediment bed and in the water column?
- What is the potential for erosion, transport and re-deposition of particle-associated chemicals buried below the surface-layer of the bed during high-flow events or storms at different locations within the Study Area?

- What effects do chemical concentrations in the surface-layer of the sediment bed have on total (i.e., dissolved and particle-associated) chemical concentrations in the water column?

2.4 Contaminants of Potential Concern

During baseline ecological and human health risk (i.e., BHHRA, BERA) screening, primary and secondary contaminants of potential concern (COPCs) were identified during preparation of the SAP and RI/FS Work Plan. Dioxins/furans were selected as an indicator chemical group consistent with EPA 1988 to assist in streamlining and simplifying RI/FS activities and eventual remedial actions. The primary and secondary COPCs are listed in Table 1.

Table 1
Primary and Secondary COPCs

Type of COPC	BHHRA Chemicals	BERA Chemicals
Primary	Dioxins and furans Aluminum Copper Mercury	Dioxins and furans Aluminum Copper Magnesium Mercury
Secondary	Magnesium Thallium 2,3,4,6-tetrachlorophenol Carbazole Chloroform Polychlorinated biphenyls (PCBs)	Thallium 2,3,4,6-tetrachlorophenol Carbazole Chloroform Polychlorinated biphenyls (PCBs)

Section 1.7.2 of the SAP and Appendix C of the RI/FS Work Plan describes in detail how the various components of the sediment study address COPCs. In regard to COPCs, unless otherwise discussed, work tasks described in this Addendum will be conducted commensurate with that section, with regard to COPCs.

3 MODELING FRAMEWORK AND APPROACH

Conducting a chemical fate and transport modeling study will produce information that reliably represents current and future conditions in the Study Area and that can be used for decision making. The development of hydrodynamic, sediment transport, and chemical fate and transport models will make it possible to understand how sediment and chemicals are transported into, within, and out of the Study Area, as well as the ultimate fate of these chemicals. Results of the chemical fate and transport modeling study will include predictions of the spatial and temporal variability of chemical concentrations in the water column and sediment bed. In addition, the models can be used to quantitatively evaluate the effectiveness of potential remedial actions.

3.1 Description of Modeling Framework

The modeling framework that will be applied to the Study Area consists of three sub-models that are linked together: hydrodynamic, sediment transport, and chemical fate and transport models. The physical and chemical processes incorporated into the modeling framework, and linkages between the sub-models are shown on Figure 2. The three sub-models are seamlessly linked together. Water-column transport information (e.g., water depths, current velocities, turbulent diffusivity) is transferred from the hydrodynamic model to the sediment transport and chemical fate and transport models. Current velocity information is used in the sediment transport model to calculate bed shear stress, which affects erosion and deposition processes. Sediment transport information (i.e., suspended sediment concentrations, erosion fluxes, and deposition fluxes) is transferred from the sediment transport model to the chemical fate and transport model.

The hydrodynamic model simulates the movement of water in the San Jacinto River and it accounts for the effects of the following factors on water movement: freshwater inflow from upstream of the Study Area; tides; spatially variable bathymetry and geometry; and estuarine circulation resulting from density differences between seawater and freshwater. The hydrodynamic model is used to simulate temporal and spatial changes in water depth, current velocity, and bed shear stress.

The sediment transport model is used to simulate temporal and spatial changes in: suspended sediment concentrations in the water column; bed elevation (i.e., bed scour depth, net sedimentation rate); sediment bed composition (i.e., relative amounts of clay, silt, and sand from different sources); and deposition and erosion fluxes across the sediment-water interface. The sediment bed in the Study Area is composed of sediment particles which range in clays to gravels. Simulation of the entire particle size spectrum is impractical for several reasons: simulation times and array-storage requirements increase with each particle-size class that is added; limitations in grain size distribution data for the sediment bed make it difficult to specify initial conditions for the entire spectrum; and sparse data for the composition of the external sediment load make it problematic for specifying this boundary condition for the entire spectrum. Therefore, particles will be separated into four size classes: 1) clay and silt with particle diameters less than 62 μm; 2) fine sand (62 to 250 μm); 3) medium and coarse sand (250 to 2,000 μm); and gravel (greater than 2,000 μm). Grain size distribution data collected from the Study Area will be used to estimate the effective particle diameters of the four sediment size classes. The model is able to track sediments from multiple sources. For example, a simulation might be conducted to track sediments from two sources: 1) upstream load; and 2) original bed. This simulation would be accomplished by separating sediment from the two sources into four size classes (i.e., classes 1, 2, 3, and 4), with the sediment transport characteristics of the four size classes being the same for each source (i.e., a total of eight sediment classes would be simulated in the model). For example, the erosion, deposition, and transport of class 1 sediment are treated the same way for sediment originating from the upstream load and original bed sources.

The chemical fate and transport model simulates temporal and spatial changes in: dissolved and particulate chemical concentrations in the water column; and chemical concentrations in the sediment bed. In addition, the model may be used to calculate: chemical fluxes across the sediment-water interface due to erosion, deposition, and diffusive flux of dissolved-phase chemicals; chemical fluxes across the air-water interface due to volatilization and atmospheric deposition; and mass balances on the water column and sediment bed.

The hydrodynamic model that will be applied in this study is the Environmental Fluid Dynamics Code (EFDC), which is supported by USEPA. EFDC is a three-dimensional hydrodynamic model capable of simulating time-variable flow in rivers, lakes, reservoirs, estuaries, and coastal areas. The model solves the conservation of mass, momentum and salt equations, which are the fundamental equations governing the movement of water in an estuary. The effects of density-driven processes on circulation in an estuary, such as the San Jacinto River, are incorporated into EFDC. In addition, the model includes a sophisticated turbulence closure algorithm that simulates the effects of vertical turbulence on estuarine circulation. A characteristic of EFDC that is of importance for this study is the flooding-drying feature, which makes it possible to realistically simulate the flooding and drying of inter-tidal areas caused by tidal action in the Study Area. The model has been applied to a wide range of environmental studies in large number of rivers, estuaries and coastal ocean areas. A complete description of the model is given in Hamrick (1992).

The sediment transport model is capable of simulating the movement of sediment by suspended load (i.e., primarily clay, silt, fine sand) and bed-load transport (i.e., near-bed movement of coarse sand and gravel). Bed-load transport is the movement of sand and gravel in a thin layer (i.e., about 1 millimeter [mm] to 1 cm thick) just above the sediment surface. Mechanistic formulations and algorithms are used in the sediment transport model to simulate deposition and erosion of cohesive (muddy) and non-cohesive (sandy) sediment. The formulations and algorithms used to simulate deposition and erosion are based on empirical information and data from a wide range of laboratory and field studies. In addition, site-specific data will be used to determine various parameters used in the sediment transport model, which provides additional constraints on the model. The sediment transport model used in this study, referred to as SEDZLJ, is capable of simulating erosion and deposition of sediment within cohesive and non-cohesive bed areas (Ziegler et al. 2000; Jones and Lick 2001; QEA 2008). The sediment transport model has the following characteristics and capabilities: 1) three-dimensional transport of suspended sediment in the water column; 2) use of Sedflume core data to specify erosion rate parameters; 3) specification of spatially variable bed properties; and 4) inclusion of a sediment bed model that tracks temporal changes in bed composition (i.e., sediment particle size, sediment source). The sediment transport model predicts the transport and fate of inorganic sediment; the transport and fate of organic solids is not simulated by the model. A detailed description of the formulations used in and structure of the sediment transport model is provided in (QEA 2008).

The chemical fate and transport model, termed QEAFATE, predicts changes in water column and sediment bed concentrations of chemicals; a description of the underlying theory can be found in Connolly et al. (2000) and Imhoff et al. (2003). QEAFATE is built into the EFDC framework that includes sediment transport based on the SEDZLJ algorithm. As such, QEAFATE is seamlessly linked with the hydrodynamic and sediment transport models. Chemical fate and transport processes simulated in this model include, but are not limited to:

- Advective and dispersive transport of chemicals within the water column
- Partitioning of chemicals between the dissolved and particulate phases in the water column and sediment bed
- Diffusive flux of dissolved-phase chemicals at the sediment-water interface
- Volatilization of chemicals at the air-water interface
- Generalized kinetic reactions (e.g., biological degradation)

Chemical fate within the sediment bed is directly coupled with that in the water column, and chemical transport associated with deposition and erosion (which is computed by the sediment transport model), molecular diffusion within sediment pore water, and particle mixing (i.e., bioturbation) are simulated within the sediment bed. The bed model is specified in multiple layers (including the specification of a mixing depth and rate to represent bioturbation) that accounts for deposition and erosion of bed material; this formulation allows for simulation of vertical chemical gradients, and accounts for dynamic vertical transport of chemicals from and to a deeper sediment reservoir. The depth of mixing in the surface layer of the sediment bed will be determined through analysis of vertical profiles of chemical concentrations and radioisotope activity from sediment cores collected within the Study Area. Similar mixing depth studies have been conducted in Lavaca Bay and Patrick Bayou, with the results of those studies producing an estimate of 10 cm for the depth of the mixing layer.

The QEAFATE model framework has been successfully applied at a number of sites across the country, including: 1) being documented in a number of peer-reviewed technical publications (e.g., Connolly et al. 2000; Ziegler et al. 2000); 2) being reviewed and accepted by regulatory agencies (Alcoa 2001, 2002, 2003; HydroQual 1998; QEA 2005); and 3) being favorably evaluated by the USEPA modeling group in Athens, Georgia (Imhoff et al. 2003). Contaminated sediment sites where the SEDZLJ and QEAFATE models have been applied include: Upper Hudson River (New York); Grasse River (New York); Housatonic River (Massachusetts); Lower Duwamish Waterway (Washington); Lower Willamette River (Oregon); Patrick Bayou (Texas); Lower Fox River (Wisconsin); and Kalamazoo River (Michigan).

3.2 Phased Approach for Model Development and Application

Evaluating chemical fate and transport will be accomplished using a phased approach because of the complex interactions between the waste impoundments area and the San Jacinto River. A phased approach is the most efficient method for studying chemical fate and transport within the Study Area. Three phases for the chemical fate and transport study are proposed:

- Phase 1: Hydrodynamic Modeling
- Phase 2: Sediment Transport Modeling and Analysis
- Phase 3: Chemical Fate and Transport Modeling and Analysis

An important component of the modeling study is to support development and refinement of CSMs for sediment transport and chemical fate and transport in the Study Area. A CSM is a useful tool for understanding fate and transport processes. In general, a CSM is a narrative or graphical representation of processes that influence the transport and fate of physical media (e.g., water, sediment) and chemicals within a Study Area of interest. Conceptual site models may incorporate both spatial and temporal components.

3.2.1 Phase 1: Hydrodynamic Modeling

The primary objectives of this phase are: 1) conduct field studies to support modeling study; 2) verify and/or modify the preliminary CSM; and 3) develop and calibrate the hydrodynamic model. The main tasks that will be conducted during this phase are:

- Compile and analyze available data related to:
    1. Hydrology and hydrodynamics
    2. Sediment transport
    3. Chemical fate and transport
- Develop preliminary CSMs for:

1. Sediment transport
2. Chemical fate and transport

- Conduct field studies to support modeling study.
- Analyze hydrodynamic data.
- Develop, calibrate and validate the hydrodynamic model.
- Use the hydrodynamic model as a diagnostic tool to develop insights about sediment transport and chemical fate and transport within the Study Area.
- Refine CSMs for sediment transport and chemical fate and transport.
- Refine design of Phase 2 as necessary.

Development of the hydrodynamic model will include generation of a numerical grid; the same numerical grid will be used for the hydrodynamic, sediment transport, and chemical fate and transport models. A rectangular grid will be used due to the complex geometry of the Study Area. It is envisioned that the size of the square grid cells will range between 15 and 30 meters, which will be sufficient for adequately simulating sediment transport and chemical fate and transport processes in the Study Area, as well as evaluating remedial alternatives during the FS. Approximate locations of the downstream boundaries of the model are shown in Figure 4.

3.2.2 Phase 2: Sediment Transport Modeling and Analysis

The primary objectives of Phase 2 are to: 1) develop and calibrate the sediment transport model; 2) determine reliability of the model; 3) use the model as a diagnostic tool; and 4) refine the CSM. The main tasks of this phase are:

- Analyze sediment transport data collected during field studies conducted to support Phase 1.
- Develop and calibrate the sediment transport model. It is anticipated that the model calibration will include a multi-year simulation (e.g., 20 years) so that long-term trends in bed elevation changes and net sedimentation rates can be evaluated. Similar multi-year simulations may be used during the FS.
- Conduct sensitivity analysis to evaluate model reliability.
- Use the sediment transport model as a diagnostic tool to:

    1. Develop insights about sediment transport and chemical fate and transport within the Study Area.

2. Evaluate sediment stability during floods/storms and over multi-year periods.
3. Answer primary study questions related to sediment transport.

- Refine CSMs for sediment transport and chemical fate and transport.
- Refine design of Phase 3 as necessary.

3.2.3 Phase 3: Chemical Fate and Transport Modeling and Analysis

The main objectives of the final phase of the modeling study are: 1) develop and calibrate the chemical fate and transport model; 2) determine reliability of the model; 3) use the model as a diagnostic tool; and 4) refine the CSM. The primary tasks of Phase 3 are:

- Analyze chemical fate and transport data collected during field studies.
- Develop and calibrate chemical fate and transport model.
- Conduct sensitivity analysis to evaluate model reliability.
- Conduct a diagnostic analysis with the model to:
  1. Develop insights about chemical fate and transport within the Study Area.
  2. Evaluate the rate of natural recovery throughout the Study Area.
  3. Answer primary study questions related to chemical fate and transport.
- Refine CSM for chemical fate and transport.
- Use the model to quantitatively evaluate the effectiveness of potential remedial actions during the FS.

The main focus of Phase 3 will be on the fate and transport of various dioxin congeners within the Study Area. Based on a preliminary analysis of sediment bed data collected in the Study Area, two dioxin congeners that will be included in the modeling analysis are 2378-TCDD and 2378-TCDF. Other dioxin congeners may be included in the model analysis based on an evaluation of bed data collected during the RI/FS nature and extent study.

4 DATA GAPS AND DATA QUALITY OBJECTIVES

4.1 Data Gaps and DQOs: Hydrodynamic Model

Development of the hydrodynamic model, which includes construction of the numerical grid, will require the following types of site-specific data:

- Bathymetry and geometry of the San Jacinto River and banks
- Freshwater inflow from the San Jacinto River (upstream boundary) and tributaries
- Water surface elevation and salinity at the downstream boundary

Calibration and validation of the hydrodynamic model will require the following data:

- Current velocities (magnitude and direction)
- Water surface elevation
- Salinity

A review of available data for the Study Area indicates that the following data gaps exist:

- Bathymetry in the regions located upstream and downstream of the waste impoundments area
- Calibration data, including current velocity, water surface elevation, and salinity

Sources of data and information to meet the other needs of the hydrodynamic model are listed in Table 2.

Table 2
Data Sources for Hydrodynamic Model Development and Calibration

Data Need	Data Sources
Bathymetry and geometry	NOAA Nautical Chart bathymetry data; multi-beam bathymetry data collected during 2009 in vicinity of waste impoundments
Freshwater inflow from San Jacinto River	Coastal Water Authority discharge at Lake Houston dam; USGS gauging stations on San Jacinto River
Water surface elevation and salinity at the downstream boundary	NOAA tidal gauge station at Battleship Texas State Park

The DQOs for the hydrodynamic model development and calibration are:

- Obtain bathymetry data in general accordance with USACE Hydrographic Survey Manual EM 1110-2-1003 (January 2002). These data will be used to realistically represent the geometry of the Study Area in the model and will have the following characteristics:
    1. Horizontal and vertical data acquisition to sub-meter accuracy
    2. Data obtained relative to HGSCD 33 TSARP monument
    3. Data reproduced in U.S. feet within Texas South Central NAD 83 (horizontal) and NAVD 88 (vertical) coordinate systems.
- Obtain water surface elevation, current velocity, and salinity data in general accordance with USGS Report 2005-5183 (Quality Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers) using an ADCP equipped with a conductivity, temperature and depth (CTD) sensor.

4.2 Data Gaps and DQOs: Sediment Transport Model

Developing a sediment transport model of the Study Area requires the following data and information:

- Magnitude and composition of sediment loads from the San Jacinto and other tributaries
- Bulk bed properties, including grain size distribution and dry density
- Delineation of cohesive (muddy) and non-cohesive (sandy) bed areas
- Erosion properties of cohesive bed sediment

Calibration and validation of the sediment transport model will require these types of data:

- Net sedimentation rates or bed elevation change
- Total suspended sediment (TSS) concentration

The two primary challenges for developing and applying a sediment transport model of the Study Area are:

- Specifying the spatial distribution of bed properties
- Estimating the magnitude and composition of external sediment loads

Delineating areas of cohesive and non-cohesive sediment throughout the entire Study Area is the first step in model development. This delineation is necessary because the erosion properties of these two types of sediment are significantly different. Within non-cohesive bed areas, specification of the spatial distributions of median particle diameter (D_{50}) and bed composition (i.e., clay/silt/sand/gravel content) is necessary for model simulations. Within the cohesive bed area, spatial variations in erosion properties (vertical and horizontal) and bed composition need to be incorporated into the model.

External sediment loads have a primary controlling effect on net sedimentation rates within an estuarine system. The composition of the incoming loads (i.e., relative amounts of clay/silt/sand) is as equally important as the load magnitude. High-flow events are the focus of a sediment load study because, typically, a majority of the annual load occurs during a small number of high-flow events. Accurate sampling during high-flow events can be difficult and challenging, particularly for obtaining composition data.

A review of available data for the Study Area indicates that the following data gaps exist:

- Magnitude and composition of sediment loads from the San Jacinto and other tributaries
- TSS concentration
- Bulk bed properties, including grain size distribution and dry density
- Delineation of cohesive (muddy) and non-cohesive (sandy) bed areas
- Erosion properties of cohesive bed sediment
- Net sedimentation rates or bed elevation change

The DQOs for the sediment transport model development and calibration are:

- Obtain sediment cores from representative locations in the Study Area for Sedflume and geotechnical testing in accordance with ASTM D 1452. Specifically, cores will be obtained to provide:
    1. Sediment suitable for Sedflume testing using procedures described in Appendix A, which will provide data related to erosion properties of cohesive bed sediment.

2. Grain Size Distribution (GSD; in accordance with ASTM D 422) and dry density (in accordance with ASTM 4254) data for model inputs related to sediment bed properties.
3. Age-dating of radioisotope sediment cores (in accordance with ASTM C 1402-04) to estimate net sedimentation rates.

- Obtain TSS concentration data (in accordance with ASTM D 3977) to develop estimates of sediment loading in the San Jacinto River from upstream sources.
- Obtain surface sediment characteristic data by manual probing, such that the bed type in a specific location can be estimated to be either cohesive or non-cohesive.

4.3 Data Gaps and DQOs: Chemical Fate and Transport Model

The data and information required for developing a chemical fate and transport model of the San Jacinto River estuary includes:

- Magnitude of external loads of dioxin congeners from the San Jacinto River
- Dioxin congener loads due to atmospheric deposition
- Spatial distribution of dioxin congener bed concentrations (vertical and horizontal variations) used for specifying initial conditions
- Parameters for kinetic processes (e.g., partition coefficients, volatilization parameters, total organic carbon [TOC] content of bed sediment)
- Depth of mixing layer in surface sediment

Partition coefficients for different dioxin congeners, which determine the relative amounts of dissolved- and particle-phase concentrations in the water column and sediment bed, have a range of values. Differences in dissolved-particle phase partitioning may result in differences in the transport and fate of various dioxin congeners within the Study Area. The chemical fate and transport model (QEAFATE) is able to incorporate the effects of differences in partitioning between dioxin congeners into fate and transport simulations.

Calibration and validation of the dioxin fate and transport model will require these types of data:

- Rate of temporal change of dioxin congener concentrations in the surface-layer of the sediment bed

- Water-column dioxin congener concentrations

Similar to estimating external loads for the sediment transport model, the accurate specification of external dioxin congener loads is a challenge for this modeling study. However, information and data on dioxin congener loads from the San Jacinto River were developed during the total maximum daily load (TMDL) study for dioxins in the Houston Ship Channel (University of Houston and Parsons 2008). Developing accurate representations of horizontal and vertical distributions of bed concentrations for specification of initial conditions may be difficult due to the spatial variability (vertical and horizontal) of various dioxin congeners.

A review of available data for the Study Area indicates that the following data gaps exist:

- Rate of temporal change of dioxin congener concentrations in the surface-layer of the sediment bed

Sources of data and information to meet the other needs of the dioxin fate and transport model are listed in Table 3.

Table 3
Data Sources for Chemical Fate and Transport Model Development and Calibration

Data Need	Data Sources
Magnitude of external loads of dioxin congeners from San Jacinto River	Dioxin TMDL modeling study
Dioxin congener loads due to atmospheric deposition	Dioxin TMDL modeling study
Spatial distribution of dioxin congener bed concentrations used for specifying initial conditions	RI/FS sediment nature and extent study
Parameters for dioxin kinetic processes	Peer-reviewed scientific literature and RI/S sediment nature and extent study
Water-column dioxin congener concentrations	Dioxin TMDL modeling study

The DQOs for the chemical fate and transport model development and calibration are:

- Radioisotope cores collected for the sediment transport model will be analyzed to estimate net sedimentation rates. For each radioisotope core that has adequate data for estimating a net sedimentation rate, archived samples from that core will be analyzed for dioxin/furan concentrations (EPA 1613B/8290A) at suitable depth intervals in the core. The dioxin/furan concentration and net sedimentation rate data will be used to estimate the rate of temporal change of dioxin/furan concentrations in the surface-layer of the sediment bed.

5 FIELD STUDIES TO SUPPORT MODELING STUDY

The data gaps described in Section 4 will be fulfilled by conducting various field studies to collect hydrodynamic, sediment transport, and chemical fate and transport data. A summary of the potential field studies to support the modeling study is provided in Table 4.

Table 4
Potential Field Studies to Support Modeling Study

Model	Data Gap	Type of Field Study
Hydrodynamic	Current velocity, water surface elevation, salinity	Deployment of ADCP with CTD sensor
Hydrodynamic	Bathymetry, upstream and downstream of the primary Study Area	Bed elevation along transects
Sediment Transport	Delineation of cohesive and non-cohesive bed areas	Sediment bed probing survey
Sediment Transport	Erosion rate properties of cohesive sediment	Sedflume testing of sediment cores
Sediment Transport	Bed property data (grain size distribution, dry density)	Surface-layer sediment cores (0-10 cm)
Sediment Transport	Net sedimentation rates	Age-dating of radioisotope cores
Sediment Transport	Upstream sediment load	Water-column sampling of TSS concentration
Sediment Transport	TSS concentrations	Use upstream load data
Chemical Fate and Transport	Rate of temporal change of dioxin congener concentrations in the surface-layer of the sediment bed	Chemical concentration analysis of radioisotope cores

5.1 Sampling Procedures

The field tasks described in the sections below will follow procedures described in the SAP (Anchor QEA and Integral 2010) that has been previously submitted and approved by USEPA. Additional field procedures not included in the original SAP are provided in this SAP Addendum.

5.2 Data Validation and Usability, Analytical Methods and Quality Control

As part of the RI/FS, data generation and acquisition procedures were described in the SAP (Anchor QEA and Integral 2010). Laboratory and analytical methods were described in Section 2.4 of the SAP; quality control procedures to be followed in the field and by selected laboratories are described in Section 2.5 of the SAP; and data validation and usability is discussed in Section 4 of the SAP. Additionally, quality assurance/quality control procedures are discussed and/or referenced in this SAP Addendum as needed.

5.3 Field Studies to Support Hydrodynamic Modeling

The two tasks discussed below are designed to support development and calibration of the hydrodynamic model of the San Jacinto River in the vicinity of the Site. Data developed during these tasks will also be used to support future work to answer additional study questions and in development of remedial alternatives for the Site.

5.3.1 Current Velocity Study

Anchor QEA will deploy one ADCP equipped with a CTD sensor in the vicinity of the waste impoundments within the Study Area in at least 6 feet of water depth and record data continuously or every 15 minutes. The ADCP will be deployed for a one-month period that will be coincident with deployment of the automated sampler for the upstream sediment load study (see Section 5.4.4). It is envisioned that at least two high-flow events will occur during this period. If two high-flow events do not occur during the one-month period, then the sampling will be extended until the desired number of high-flow events has occurred. The mean flow rate in the San Jacinto River is 2,200 cfs, and high-flow events with return periods of 2, 10, and 100 years correspond to flow rates of 31,600, 107,000 and 329,000 cfs, respectively. For the purposes of the current velocity study, a high-flow event will be considered to be an event with a peak flow rate of 10,000 cfs or greater. If the magnitude of high-flow events during the data collection period does not reflect a suitable range of conditions (as determined by the project technical team) or if baseline conditions are not re-established between events to sufficiently identify distinct events, the data collection period may be extended on a bi-weekly basis.

The ADCP uses a type of sonar technology that measures and records water current velocities over a range of depths. An ADCP transmits sound bursts into the water column and suspended particles carried by water currents produce echoes (from these sound bursts). These echoes are "heard" by the ADCP with echoes arriving later, from deeper in the water column, assigned greater depths in the echo record. This allows the ADCP to form vertical profiles of current velocity. The ADCP senses water movement in four orthogonal directions simultaneously, with particles within the current flow moving towards the instrument exhibiting different frequencies from those moving away. This process is known as the Doppler shift, which enables the precise measurement of current speed and direction.

ADCP units have been commercially available for over 25 years and are being used in a variety of industries including oceanography, meteorology (used in weather forecasting), shipping (to monitor tides/currents for optimizing shipping in busy ports) and monitoring applications related to sewer and stormwater monitoring. Within the environmental engineering field, ACDPs have been deployed by the USACE for use as part of model development and calibration for determining dispersion of dredged materials from plumes emanating from dredge sites (i.e., USACE SSFATE model). Additionally, the U.S. Geologic Survey (USGS) has been employing ADCPs since 1985 for measuring stream flow in rivers. A Quality Assurance Project Plan (QAPP) for using these instruments when deployed from research vessels has been developed by the USGS (2005) and will be followed during this project where applicable.

The unit deployed will be a Workhorse ADCP manufactured by Teledyne RDI; a datasheet for the Workhorse ADCP is included in Appendix B for reference. This unit is capable of long-term data logging and will be equipped with a CTD. Both the ADCP and CTD data will be recorded in the internal memory of the ADCP. The location of the ADCP/CTD will be surveyed by Anchor QEA staff or a sub-contractor and a reference location will be established to convert changes in water depth measurements to elevations. The location and elevation information will be given in Texas South Central NAD 83/NAVD 88 coordinate system.

The ADCP/CTD will be deployed and operated following manufacturer's instructions and applicable guidance (USGS 2005). An appropriate interval for downloading data and performing systems checks will be determined from the operating manual.

5.3.2 Bathymetric Survey

A bathymetric survey of the preliminary Site perimeter will be completed by a sub-contractor to map the topography and features of the river bed in that region. Additional survey transects will be completed in the regions located upstream and downstream of the primary Study Area (Figure 3) to provide data for development of the hydrodynamic model. In addition to the modeling study, the bathymetric survey data will be used for a range of purposes during the RI/FS. The bathymetric survey will be performed using electronic survey techniques for both horizontal and vertical data acquisition and will be overseen by a hydrographer who is certified by the American Congress on Surveying and Mapping. At a minimum, the contractor will use a survey-grade echo sounder, operating at 200 KHz, coupled with a positioning system capable of providing sub-meter positioning accuracy. Both the echo sounder and horizontal positioning system data will be collected real-time and use software designed for hydrographic survey data acquisition (i.e., Hypack, HydroPro). The contractor will prepare a survey transect plan that will be sufficient to properly represent the river bathymetry and geometry in the primary Study Area, as well as the regions located upstream and downstream of the primary Study Area.

Within the primary Study Area, the bathymetric survey will have sufficient areal coverage to produce a 3-foot by 3-foot grid surface from the bed elevation data obtained during the survey. The contractor will prepare a survey transect plan that will be sufficient to meet this requirement. In the region upstream of the primary Study Area, a total of 15 cross-channel transects will be surveyed. In the region downstream of the primary Study Area, a total of 12 cross-channel transects will be surveyed as shown in Figure 3. The cross-channel transects will be continuous, with XYZ data provided at 5-foot intervals in the data files. All survey procedures, data collection equipment, methods, densities and equipment calibration for this survey will follow the criteria of the Navigation and Dredging Support Surveys for soft bottom materials as given in the USACE Hydrographic Survey Manual EM 1110-2-1003 (January 2002). The survey will be performed using electronic survey techniques for both horizontal and vertical data acquisition and results will be mapped relative to HGCSD 33 TSARP monument (published elevation 26.57 NAVD88). The water elevation at the survey location will be monitored during the duration of the survey and all echo sounder data will be reduced by the water elevation readings taken during the survey.

The XYZ data gathered will be processed to produce a 3-foot by 3-foot grid surface of the Study Area and survey transects data. This will be done via development of a three-dimensional model of the data using a software package such as Trimble's "Terramodel" or a similar software suite. The transects shown in Figure 3 have been established to provide sufficient data density to facilitate model generation through the use of break lines to link points of similar elevation(e.g., following contours). This will allow the Hydrographer to guide the model development along areas of similar bed elevation based upon the XYZ data and published NOAA navigation charts. Once the model has been developed, it will be compared to the collected data to ensure that the model properly reflects the river topography. After the completion of the quality control check, the completed model will be used to generate an ASCII XYZ grid file that contains bed elevation data on a grid with 3-foot by 3-foot resolution.

5.4 Field Studies to Support Sediment Transport Modeling

Sediment sampling activities have been outlined in the submitted SAP which will assist in developing a dataset detailing the nature and extent for COPCs at the Site (see Section 2.1 of the SAP). During these sampling activities, additional sediment data will be collected, as described below, to develop several sediment transport model specific data sets.

5.4.1 Bed Property Study

As part of the SAP, a total of 68 surface samples (0 – 10 cm) will be collected for characterization of Site and impoundment surface sediment (see Table 13 from the SAP). The surface samples will be analyzed for the various COPCs. In addition, these samples will be analyzed for bulk bed properties (i.e., GSD, dry density) and these data will be used to develop inputs for the sediment transport model. Additional sampling activities are needed to supplement the bed property data in the regions located upstream and downstream of the Study Area. These activities are summarized in Figure 4 and described below.

5.4.1.1 Sediment Bed Probing

A sediment bed probing investigation will be conducted upstream and downstream of the primary Study Area. The objective of the probing study is to determine the spatial distribution of cohesive (muddy) and non-cohesive (sandy) bed areas. Access to sub-tidal stations and to some of the inter-tidal stations (particularly at high tide) will require the use of a boat. Some of the inter-tidal stations may be sampled at low tide, and accessed by land. Sampling vessels will be equipped and target locations identified in the field as described in the SAP. Sediment probing procedures to be followed are outlined below and deviations shall be noted by the field team lead, in coordination with project manager, as described in the SAP:

For locations that can only be reached via boat:

1. Using the on-board GPS system, maneuver the sampling vessel to within 5 feet of the pre-programmed target coordinates for each sample location. Secure the vessel in place using spuds and/or anchors.
2. Use a 3/8 inch steel rod, or equivalent, to probe the sediment. The probe will be sharpened at one end and marked at 6-inch intervals.
3. Advance the probe into the sediment bed, noting depth of penetration and type of resistance met by the probe.
4. Move the probe laterally several feet (while maintaining the minimum 5-foot distance from the target location) and repeat the probing at least three times.
5. Record the approximate average sediment thickness (to the nearest 0.25 foot) and the estimated sediment type (i.e., muddy (cohesive) bed, sandy (non-cohesive) bed, rocky bed) in the field log. Sediment type is estimated based on the type of resistance met by the probe.
6. If probing results are inconsistent between the three attempts, then note this inconsistency in the field log.

For locations that can be reached from shore or at low tide, the above procedures will be followed. Care will be taken to probe in a location(s) that is undisturbed (e.g., not walked over) prior to probing.

5.4.1.2 Surface Sediment Sampling

In addition to the probing study described above, various locations will be selected for surface sediment sampling. In summary, 30 additional samples are proposed to be collected. Samples will be collected as described in Section 2.2 of the SAP but will target co-located probing locations (discussed above) outside of the primary Study Area to provide grain size distribution and dry density data for the sediment transport model. These samples will serve to confirm the data gathered as part of the probing study. The bed sampling locations will be determined in the field while completing the bed probing study. Generally, 10 and 20 locations will be located upstream and downstream of the primary Study Area, respectively. The downstream locations will be divided evenly between the two channels located south of the I-10 Bridge.

5.4.2 Sedflume Study

A Sedflume study will be conducted by Sea Engineering, Inc. (SEI) to measure the erosion rates of cohesive bed sediment areas as a function of bed shear stress and depth in the bed. Sediment cores will be collected at 15 locations. The locations of these cores will be determined upon completion of the sediment bed probing study (see Section 5.4.1.1) and areas of cohesive bed sediments have been identified (i.e., only cohesive bed sediments will be tested during the Sedflume study). The general locations will be grouped into three distinct areas: 1) immediate vicinity of the waste impoundments; 2) upstream of the waste impoundments; and 3) downstream of the waste impoundments. Five cores will be collected from each of these three areas for Sedflume testing.

A detailed description of the Sedflume testing procedure is provided in the QAPP included in Appendix A to this SAP Addendum. In summary, once a sediment core obtained for Sedflume for testing has been collected, it will be inspected by SEI personnel for length and quality. Any signs of disturbance will result in that core being discarded and another collected. Once an undisturbed sample has been obtained, a plug will be inserted that will later act as a piston and the core is capped. Once at the selected processing site, the core tube will be inserted into the bottom of the straight flume, via the test section, where the Sedflume testing will occur.

The sediment cores collected for Sedflume testing will be approximately 30-cm long and erosion rate testing will be conducted over the top 25 cm of each core. Erosion rates will be measured for bed shear stresses ranging between 0.1 and 6.4 Pa. In addition to the measurement of erosion rates, particle size distribution and bulk (wet) density data will be obtained from the core samples.

5.4.3 Radioisotope Coring Study

The radioisotope coring study will be used to estimate net sedimentation rates and to age-date sediment cores. Sediment cores will be sectioned into 4-cm intervals for analysis of the radioisotopes cesium-137 (^{137}Cs) and lead-210 (^{210}Pb). The first occurrence of detectable ^{137}Cs in sediments generally marks the year 1954, while peak activities correspond to 1963. Based on these dates, the best estimate of the long-term average net sedimentation rate for a particular core is computed by dividing the depth of sediment between the sediment surface and the buried ^{137}Cs peak by the number of years between 1963 and the time of core collection (e.g., 47 years for a core collected in 2010). Lead-210, which is a decay product of volatilized atmospheric radon-222 (^{222}Rn), is present in sediments primarily as a result of recent atmospheric deposition. Radon-222 is a volatile, short-lived, intermediate daughter of uranium-238 (^{238}U), a naturally occurring radioisotope found in the earth's crust. The ^{210}Pb activity in a sediment sample represents the total ^{210}Pb activity, which is measured indirectly by analysis of its radioactive decay products bismuth-210 or polonium-210. Total ^{210}Pb activity consists of two components:

1. Unsupported ^{210}Pb, which represents ^{210}Pb that is deposited on the earth's surface at an approximately constant rate via atmospheric deposition; and
2. Supported ^{210}Pb, which is the background ^{210}Pb activity in the sediment. In aquatic environments, the approximately constant atmospheric flux of ^{210}Pb and its decay half-life of 22.3 years results in relatively homogeneous ^{210}Pb activities within the biologically-active surface layer of the sediments and activities that decay exponentially below this depth. For this reason, ^{210}Pb serves as a useful tracer for estimating net sedimentation rates and mixing depths in aquatic systems.

Radioisotope cores need to be collected from areas with a cohesive (muddy) sediment bed because non-cohesive (sandy) sediment deposits do not typically produce usable age-dating data. Ten radioisotope cores will be collected and the locations of these cores will be determined from the results of the bed probing study (i.e., cohesive bed areas). The objective of this study is to collect four radioisotope cores in the vicinity of the waste impoundments, two radioisotope cores upstream of the waste impoundments, and four radioisotope cores downstream of the I-10 Bridge.

Sediment cores will be collected as described in the SAP. Radioisotope samples will be obtained from each core using the following method. Cores will be sub-sampled in consecutive 4-cm intervals (i.e., 0 to 4 cm, 4 to 8 cm, 8 to 12 cm). Sub-samples will be submitted for laboratory analysis of ^{137}C and ^{210}Pb activity from every eighth sub-sample interval, starting with the 0 to 4 cm interval. The sub-samples that are not submitted for radioisotope analysis will be processed and archived for potential future laboratory analysis of radioisotope activity or chemical concentration. After receiving the laboratory results and analyzing the radioisotope data, those cores for which a successful age-dating analysis is able to be conducted may be selected for additional laboratory analysis of chemical concentrations, see Section 5.5.

5.4.4 Upstream Sediment Load Study

The upstream sediment load in the San Jacinto River will be estimated using TSS concentration data collected during a one-month period. These data will be collected using an automated sampler (e.g., Teledyne Isco [ISCO] portable sampler) that will be installed at the location shown in Figure 5. The sampler will be set-up to collect eight composite water samples per day (i.e., one sample every 3 hours). Sample bottles will be collected and handled in accordance with the Field Study Plan. The automated sampler will be serviced once every three days and the collected water samples will be submitted for laboratory analysis of TSS concentration as follows:

- If no rain occurred during the three-day period (based on closest HCOEM precipitation stations), the 12th water sample collected in the series will be analyzed to obtain a “baseline” TSS concentration measurement for that period.
- If at least 0.1 inch of total continuous rain occurred during the three-day period (based on closest HCOEM precipitation stations), then the precipitation record will be analyzed and samples that were collected during the rainfall event will be submitted for TSS concentration analysis. In addition, the sample collected immediately before

the onset of rainfall and all samples collected up to 12 hours after the completion of the rainfall event will be submitted for TSS concentration analysis.

It is anticipated that the automated sampler will be deployed for a one-month period. It is envisioned that at least two high-flow events will occur during this period. Once the data from these events has been processed and the data quality has been verified, collection of TSS concentration samples will be discontinued. If two high-flow events do not occur during the one-month period, then the sampling will be extended until the desired number of high-flow events has occurred. Similar to the current velocity study, a high-flow event will be considered to be an event with a peak flow rate of 10,000 cfs or greater. If the magnitude of high-flow events during the data collection period does not reflect a suitable range of conditions (as determined by the project technical team) or if baseline conditions are not re-established between events to sufficiently identify distinct events, the data collection period may be extended on a bi-weekly basis.

5.5 Field Studies to Support Chemical Fate and Transport Modeling

Information on the rate of temporal change of chemical (e.g., dioxin congener) concentrations in the surface and near-surface-layer of the sediment bed is needed for calibration and validation of the chemical fate and transport model. As described in Section 5.4.3, sub-samples for the radioisotope cores will be archived for potential analysis of chemical concentrations after the age-dating analysis is completing. It is anticipated, based on past experience with analyzing radioisotope cores at other contaminated sediment sites, that a successful age-dating analysis will not be possible for all ten cores. Additional laboratory analysis of archived sub-samples will conducted for each of the radioisotope cores that were able to be successfully age-dated.

Radioisotope cores that were successfully age-dated will have selected archived samples submitted to a laboratory for chemical concentration analysis. The method for selecting archived samples for chemical analysis will depend on the vertical profile of radioisotope activity and the location of specific time horizons in the core. The number and location of archive samples selected for a specific radioisotope core will be determined by Anchor QEA personnel after a thorough review of the results of the age-dating analysis for that core.

6 SCHEDULE

It is anticipated that task-specific planning activities for the various phases discussed above will require approximately two months from approval of the SAP Addendum. Following these planning activities, the various phases will be implemented, each lasting approximately 4 months, and overlapping the previous phase by a month, resulting in a total of 10 months to implement the three-phase modeling study. This anticipated schedule does not account for unforeseen events such as weather delays or interim agency involvement.

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FIGURES

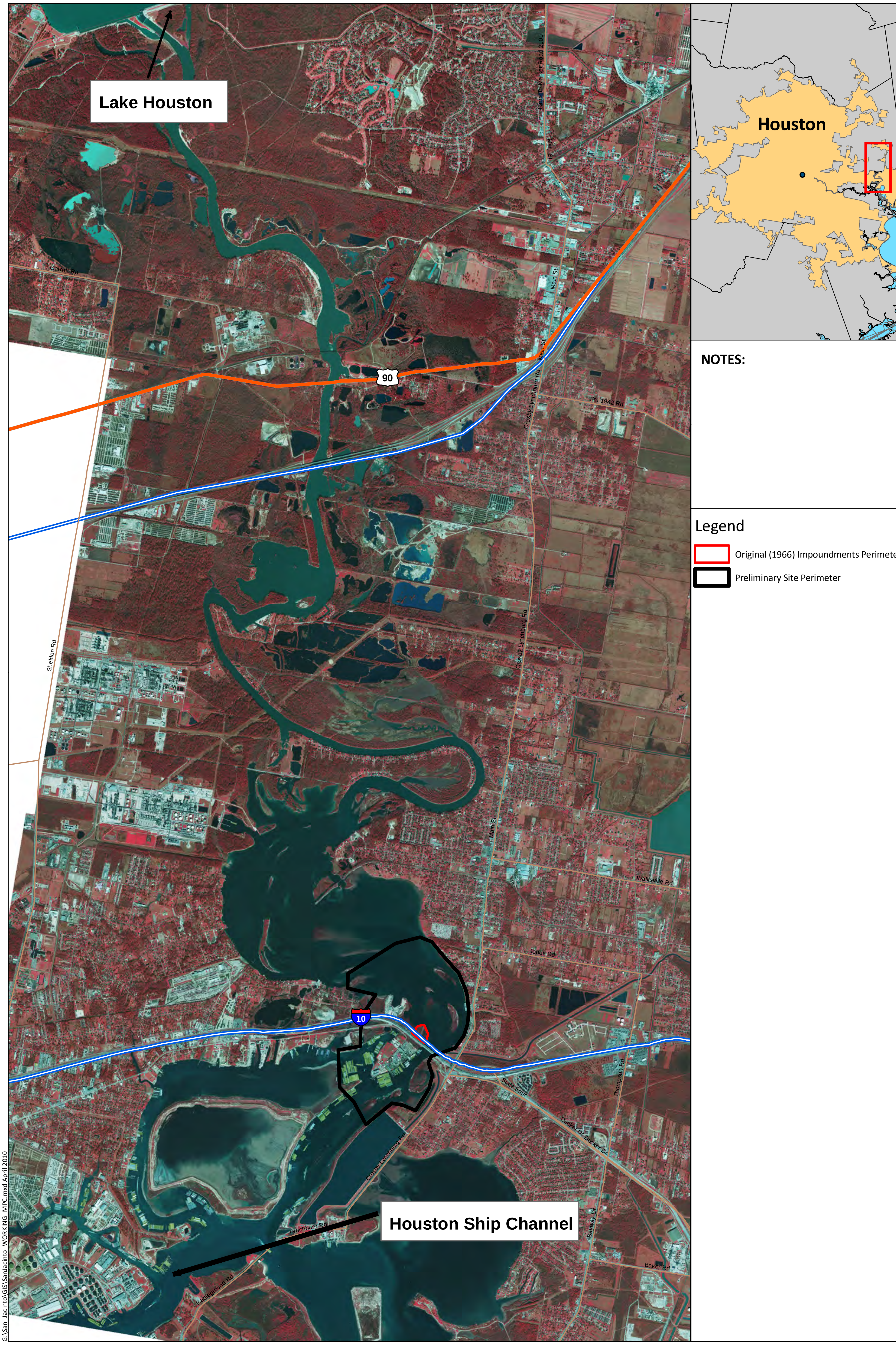

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Figure 1
Site Map
SJRWP SAP Addendum
SJRWP Superfund/ MIMC and IPC

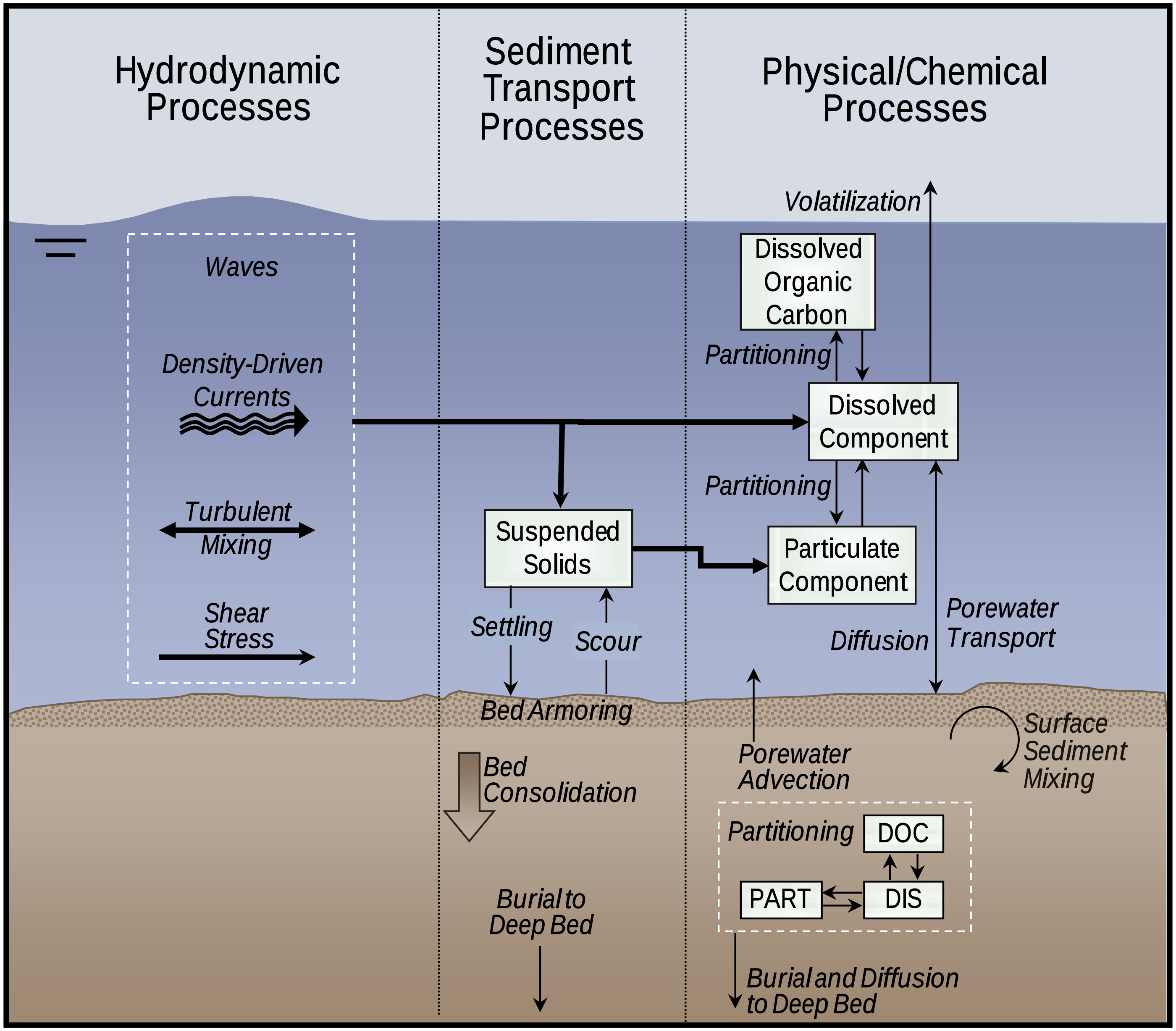

Figure 2
Physical and Chemical Processes Incorporated into the Chemical Fate and Transport Modeling Framework.
SJRWP SAP Addendum
SJRWP Superfund/MIMC and IPC

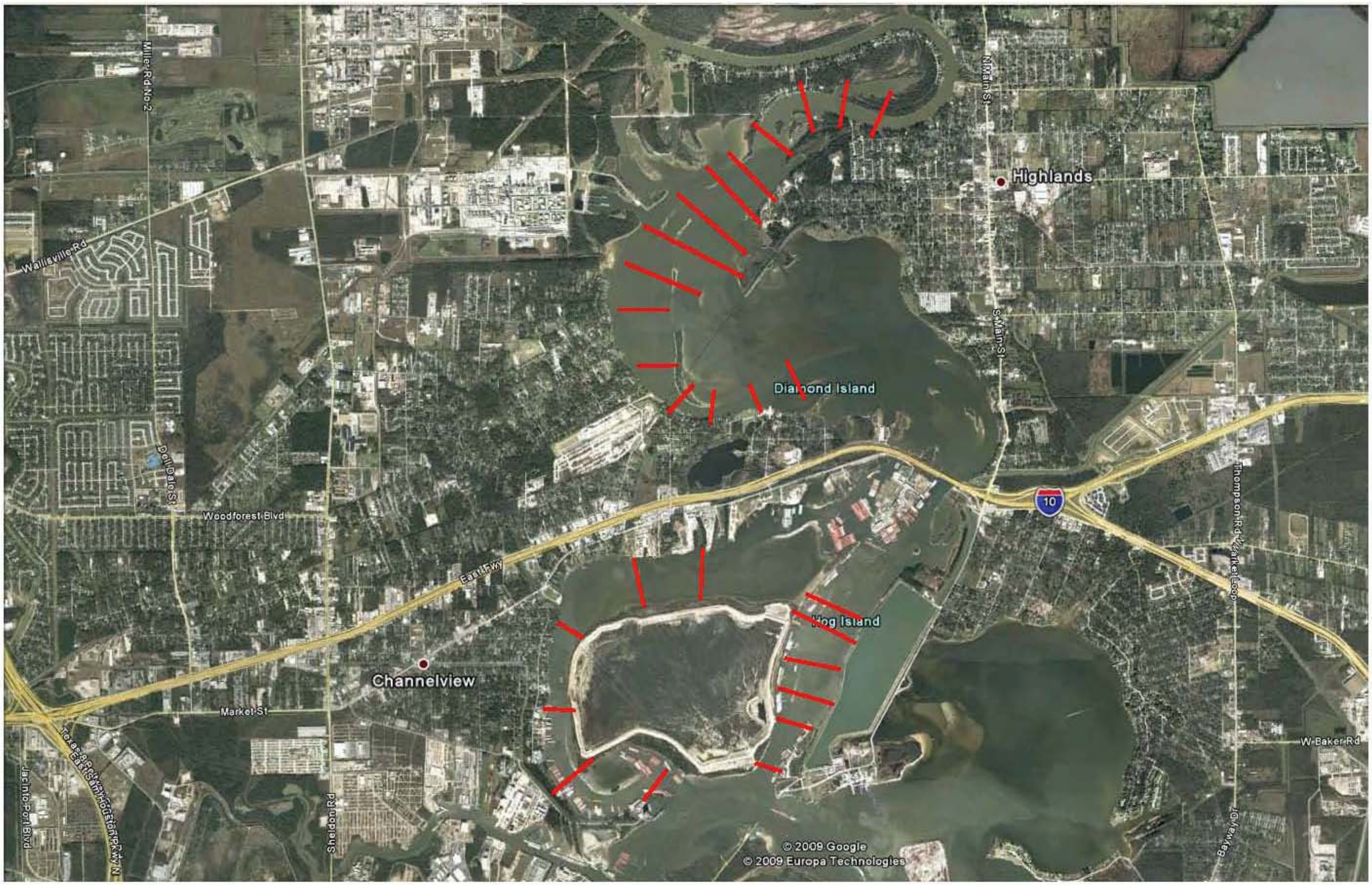

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Figure 3

Cross-channel Bathymetry Transects Located Upstream and Downstream of the Primary Study Area

SJRWP SAP Addendum

SJRWP Superfund/MIMC and IPC

NOTES:

Surface sediment samples will be collected from 30 of the locations shown in this figure.

Legend

- Probing Locations
- Original (1966) Impoundments Perimeter
- Preliminary Site Perimeter

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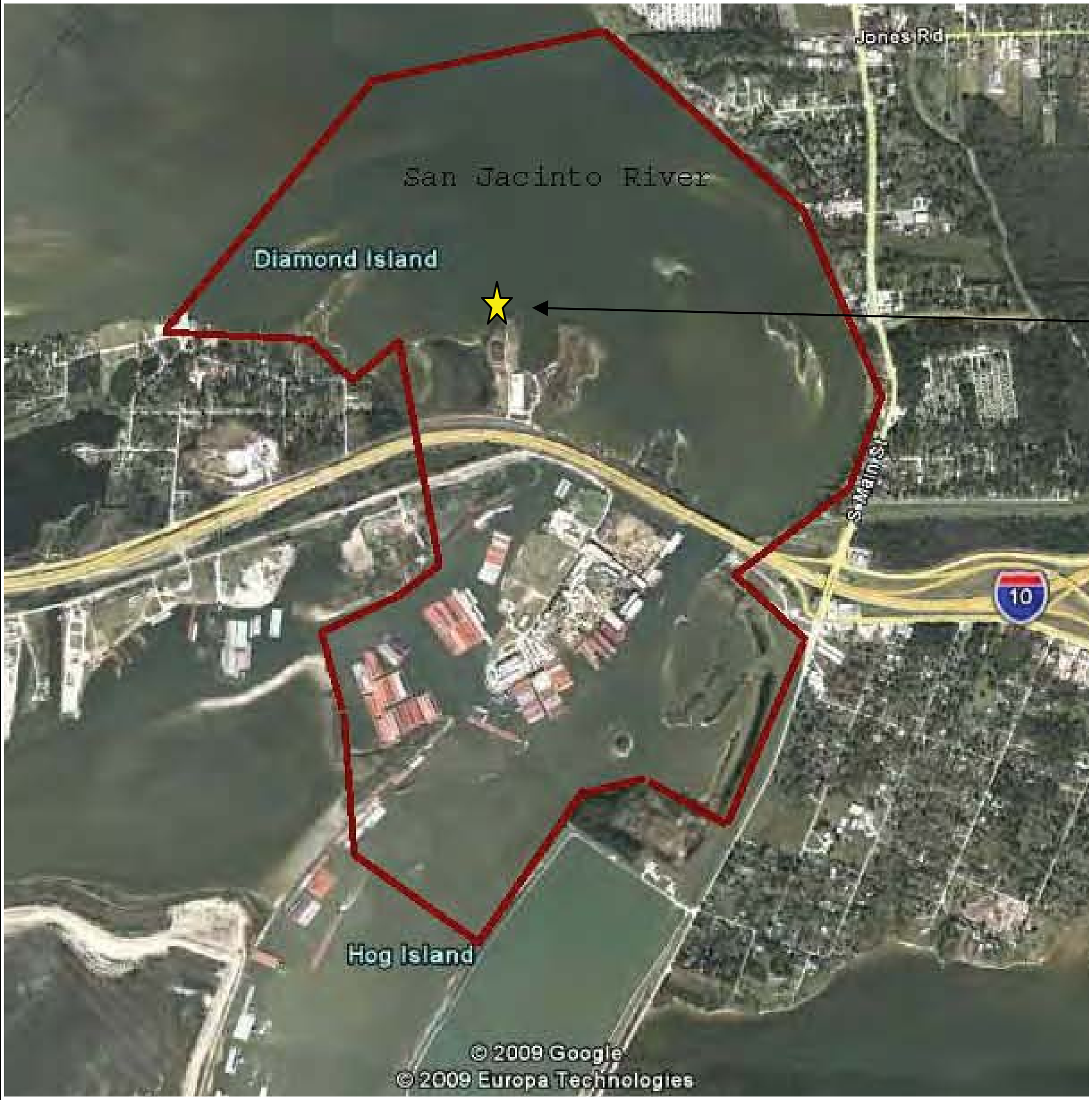
Figure 4

Bed Probing Locations for Bed Property Study

SJRWP SAP Addendum

SJRWP Superfund/ MIMC and IPC



Proposed Location for Automated Sampler Deployment

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Figure 5
Proposed Location for Automated Sampler During Upstream Load Study
SJRWP SAP Addendum
SJRWP Superfund/MIMC and IPC

APPENDIX A
QUALITY ASSURANCE PROJECT PLAN FOR SEDFLUME TESTING

Preliminary Sedflume Quality Assurance Project Plan

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Preliminary Sedflume Quality Assurance Project Plan

Introduction

Sedflume sampling will be undertaken by Sea Engineering, Inc. (SEI) to determine sediment erosion rates laterally and with depth at sites to be chosen. An undefined Sedflume cores up to 1 m in length will be taken for the analysis of erosion rates. The direct measurement of sediment erosion rates via Sedflume provides a quantitative measurement of sediment stability that can be used to determine the potential for sediment mobility in a natural system (McNeil et al., 1996). It has additionally been demonstrated that erosion rates are strongly dependent on the bulk density of the sediments (Jepsen et. al, 1997; Roberts et. al, 1978). Because of this, the densities of the Sedflume cores will be determined by sub-sampling locations within each core so that the bulk density can be determined through wet/dry sample weight. Particle size analysis will be performed at additional sub-sampled locations in the cores to provide additional characterization of the sediments. These cores will be spatially located so as to delineate the different types of sediments (clays, silts, sands, etc.) present as well as along areas where concentrations of contaminants are the highest so as to characterize potential contaminant mobility.

Figures 1 and 2 show sample Sedflume data from independent studies conducted at test sites in San Francisco Bay by SEI. Figure 1 shows variation of sediment erosion rates with depth into the sediments and shear stress. It can be seen in this plot that the surficial sediments erode easily at lower shear stresses, but at lower levels in the core the sediments are much more difficult to erode requiring much larger shear stresses. Figure 2 shows particle size and bulk density variation for the same core as Figure 1.

The objective of the Sedflume study is to characterize the erosion rates and sediment stability of sediments throughout the region of interest. Sediment characteristics such as mean particle size, particle size distribution, and bulk density will be determined with depth for each core obtained. The information collected in this study can be used to provide parameters for a sediment/contaminant transport model to estimate storm-induced resuspension of sediment and subsequent release of contaminants.

Data collected in the study will be gathered into and summarized in a detailed data report. Plots of erosion rate versus core depth and bulk parameters versus core depth will be presented for each core obtained and average erosion rates and average bulk properties will be plotted with binned depth. The erosion rate tests are conducted using cycles of shear stress (i.e., increasing from low to high applied shear stress) over a specified depth interval in the core, which is typically about 5 cm in thickness. The “binned depth” refers to a depth interval for a particular shear stress cycle. General trends in the data set will be noted and variations between different regions will be characterized. Quality assurance objectives and results will be assessed in the process of preparing the report. Measurements to be made by Sea Engineering, Inc. (SEI) are shown in Table 1. These measurements will be made by instrumentation provided by the laboratory of SEI. No other special personnel or equipment is necessary for core analysis.

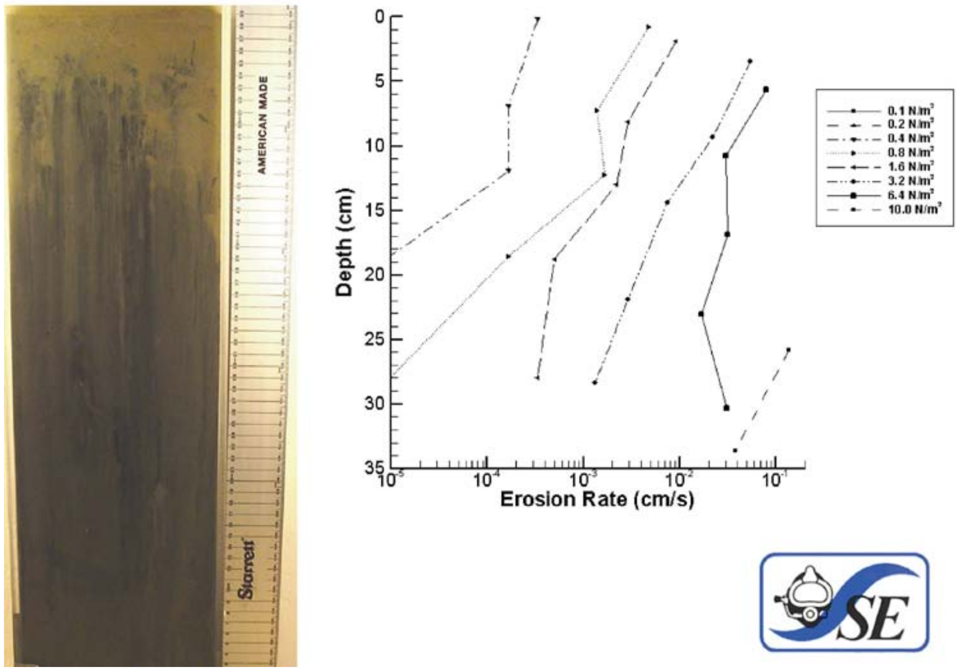


Figure 1. Erosion rate variation with depth and shear stress for San Francisco Bay location.

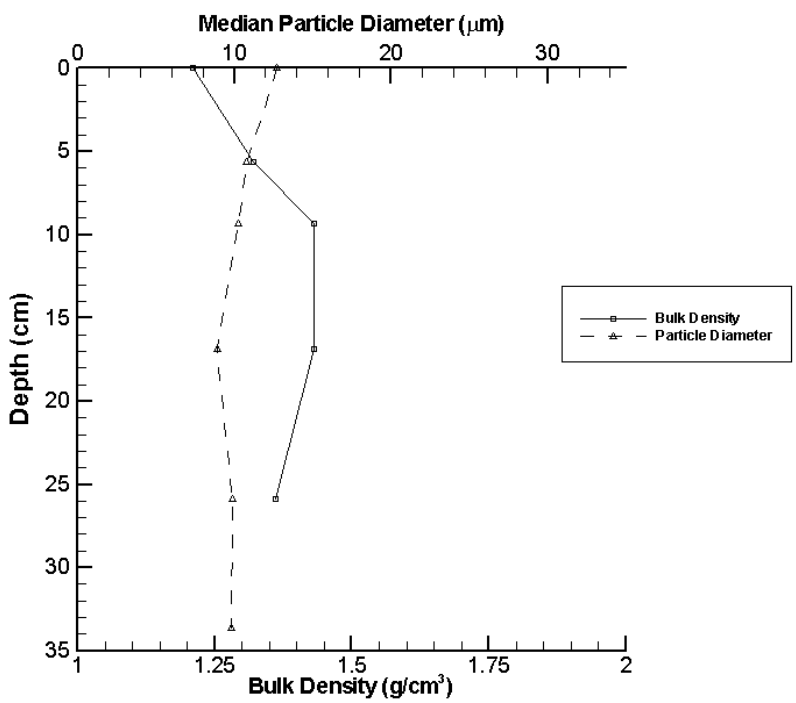


Figure 2. Variation of particle size and bulk density with depth for San Francisco Bay location.

Data Quality Objectives for Measurement Data

To achieve the project's overall data quality objectives, measurements will be made to ensure sufficient characterization of sediment bulk properties and erosion rates. The bulk properties to be measured by SEI have been chosen based on previously determined field and laboratory work (McNeil et al, 1996; Taylor et al, 1996; Jepsen et al, 1997; and Roberts et al, 1998). The parameters to be measured in the Sedflume cores are listed in Table1.

Table 1

	Definition	Units	Detection Limit	Int. Consistency
Bulk Density, ρ_b (wet/dry weight)	$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W}$	g/cm^3	Same as water content	$\rho_w < \rho_b < 2.6\rho_w$
Grain Size	Volume weighted distribution including median and mean size	μm	0.0375 μm – 2000 μm	
Water Content	$W = \frac{M_w - M_d}{M_w}$	none	0.1g in sample weight ranging from 10 to 50 g	$0 < W < 1$
Erosion Rate	$E = \Delta z/T$	cm/s	$\Delta z > 0.5$mm $T > 15$s	None

M_w = wet weight of sample
M_d = dry weight of sample
Δz = amount of sediment eroded
T = time
ρ_w = density of water
ρ_s = density of sediments
All essential bulk properties will be measured from the same core.

Field Methods

Sampling Process Designs

Sediment erosion rates will be determined horizontally and with depth. Erosion rates will be measured as a function of shear stress and depth for each core. Sediment bulk properties will also be measured for each erosion core. Bulk properties of the sediments (particle size distribution, organic content, mineralogy, and gas content) will be measured using samples from the erosion core. All essential bulk properties (including erosion rates) will be measured for the same core using this method. All measurements to be taken (Table 1) are classified as critical measurements.

Approximately 6 cores will be processed in Sedflume to determine how sediment erosion potential and bulk parameters vary spatially in the study area. The number of cores chosen represents the number required to characterize the different sediment types that exist in the region and their spatial variation, while not making the study's duration prohibitively long. Approximately one day is required to process a core in Sedflume, so 6 cores represents approximately one week in the field. Erosion rates are dependent upon, at least, the following parameters: bulk density, mean grain size, grain size distribution, gas content and organic content. Sediment erosion cannot at present be predicted through knowledge of bulk parameters. Therefore, a sufficient number of cores are necessary to present adequate average erosion rates for a given aquatic system. Preferably these averages will also be grouped in terms of size class of particles, especially delineating sands from cohesive sediments.

Coring locations will be chosen with the following tenets in mind: a) sediments known to contain a relatively large amount of contaminant must be characterized, b) a wide variety of sediment types commonly found in the area, c) and knowledge of sediment variability both spatially and with water depth is necessary as sediment resuspension and deposition are strong functions of applied shear stress and water depth. Using the above criterion as guidelines, coring transects will be selected as appropriate.

Core Collection and Preparation

In situ coring will be done in the following manner aboard the vessel selected for coring. Core tubes are inserted into a thin stainless steel sleeve. The neck of the sleeve is a 10 by 15 cm outer tube, while the main body is a circular barrel with dimensions such that the 10 by 15 cm core tube fits tightly into the barrel.

The assembled coring sleeve is lowered to the sediment bed by a pole. Appropriate methods will be chosen for the specific vessel and water depth encountered. Pressure is applied to the top of the coring pole. Due to its weight and the applied pressure, the sleeve penetrates into the sediment bed. The coring sleeve is then pushed as far as possible into the sediment bed; the distance of penetration will vary due to the characteristics of the sediment (i.e., further penetration will occur in a softer sediment than in a more compact sediment). This results in a sediment core that is obtained relatively undisturbed from its natural surroundings. The coring sleeve is then brought back up and lifted onto the boat deck and the barrel lifted off the core tube. A plug is slid up into the core tube to act later as a piston, and the core is then capped. Sediment cores varying in length from 25-60 cm will be obtained by this method.

Cores will immediately be visually inspected for length and quality. Cohesive sediments that show signs of disturbance during the coring process will be discarded and another core will be taken from that site. Approved cores will be capped and stored on deck until returned to the processing site on shore. At the processing site, samples taken from the core for bulk property analysis will be placed in appropriate sized containers, labeled, sealed, and preserved until delivered to the laboratory for analysis. Dr. Craig Jones will be responsible for corrective action regarding sample method requirements.

Sample Handling and Custody Requirements

Samples will be collected, handled, and analyzed by SEI personnel. Chain of custody will be recorded as required by project specifications.

All samples will be uniquely labeled and logged by the sampler. Samples designated for Sedflume study will be under the continuous custody of SEI personnel so the sample integrity can be assured. Dr. Craig Jones of SEI will supervise all Sedflume operations.

Analytic Methods

Description of Sedflume

A detailed description of Sedflume and its application are given in McNeil et al, 1996. Sedflume is shown in Figure 3 and is essentially a straight flume that has a test section with an open bottom through which a rectangular cross-section coring tube containing sediment can be inserted. The main components of the flume are the coring tube; the test section; an inlet section for uniform, fully-developed, turbulent flow; a flow exit section; a water storage tank; and a pump to force water through the system. The coring tube, test section, inlet section, and exit section are made of clear acrylic so that the sediment-water interactions can be observed. The coring tube shown in Figure 3 has a rectangular cross-section, 10 cm by 15 cm, and can be up to 1 m in length. Sea Engineering, Inc. additionally uses a 10 cm diameter circular core for Sedflume analysis to facilitate field collection of cores.

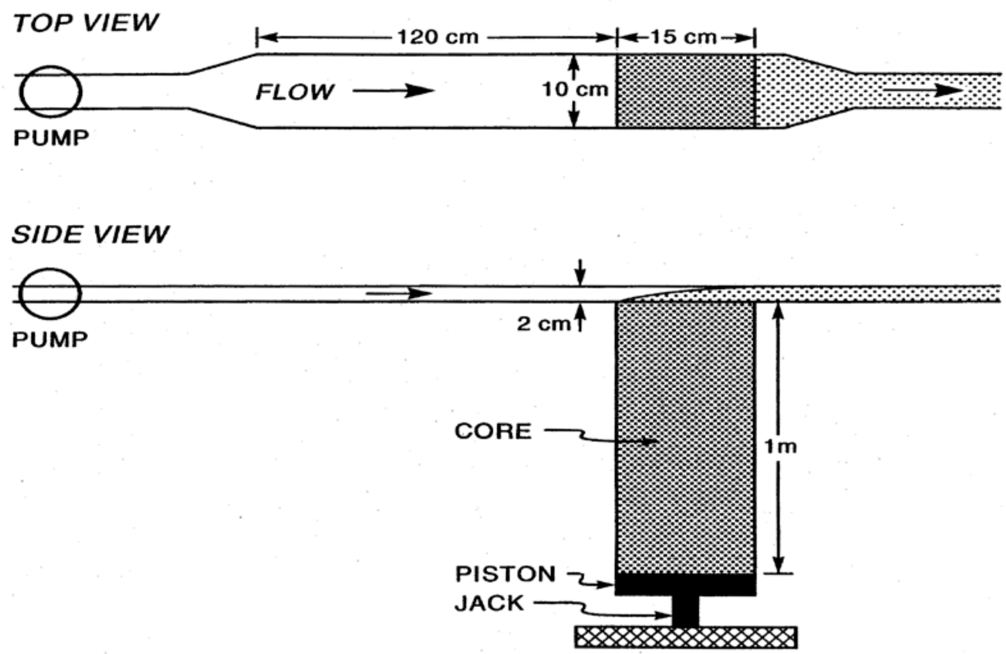


Figure 3. Schematic of Sedflume

Water is pumped through the system from a 120 gallon storage tank, through a 5 cm diameter pipe, and then through a flow converter into the rectangular duct shown. This duct is 2 cm in height, 10 cm in width, and 120 cm in length; it connects to the test section, which has the same cross-sectional area and is 15 cm long. The flow converter changes the shape of the cross-section from circular to the rectangular duct shape while maintaining a constant cross-sectional area. A three-way valve regulates the flow so that part of the flow goes into the duct while the remainder returns to the tank. Also, there is a small valve in the duct immediately downstream from the test section that is opened at higher flow rates to keep the pressure in the duct and over the test section at atmospheric conditions.

At the start of each test, the coring tube is filled with undisturbed sediments from the bottom of the body of water of interest or reconstructed sediments for consolidation studies. The coring tube and the sediment it contains are then inserted into the bottom of the test section. An operator moves the sediment upward using a piston that is inside the coring tube and is connected to a screw jack with a 1 m drive. The jack is driven by either electric motor or hand crank. By these means, the sediments can be raised and made level with the bottom of the test section. The speed of the jack movement can be controlled at a variable rate in measurable increments as small as 0.5 mm.

Water is forced through the duct and the test section over the surface of the sediments. The shear produced by this flow causes the sediments to erode. As the sediments in the core erode, they are continually moved upwards by the operator so that the sediment-water interface remains level with the bottom of the test and inlet sections. The erosion rate is recorded as the upward movement of the sediments in the coring tube over time.

Measurements of Sediment Erosion Rates

The procedure for measuring the erosion rates of the sediments as a function of shear stress and depth will be as follows. The sediment cores will be obtained as described above and then moved upward into the test section until the sediment surface is even with the bottom of the test section. A measurement is made of the depth to the bottom of the sediment in the core. The flume is then run at a specific flow rate corresponding to a particular shear stress. Erosion rates are obtained by measuring the remaining core length at different time intervals, taking the difference between each successive measurement, and dividing by the time interval.

In order to measure erosion rates at several different shear stresses using only one core, the following procedure is used. Starting at a low shear stress, the flume is run sequentially at higher shear stresses with each succeeding shear stress being twice the previous one. Generally about three shear stresses are run sequentially. Each shear stress is run until at least 2 to 3 mm but no more than 2 cm are eroded. The time interval is recorded for each run with a stopwatch. The flow is then increased to the next shear stress, and so on until the highest shear stress is run. This cycle is repeated until all of the sediment has eroded from the core. If after three cycles a particular shear stress shows a rate of erosion less than 10^{-4} cm/s, it will be dropped from the cycle; if after many cycles the erosion rates decrease significantly, a higher shear stress will be included in the cycle.

Measurements of Critical Shear Stress for Erosion

A critical shear stress can be quantitatively defined as the shear stress at which a very small, but accurately measurable, rate of erosion occurs. In the present study, this rate of erosion is chosen to be 10^{-4} cm/s; this represents 1 mm of erosion in approximately 15 minutes. Since it would be difficult to measure all critical shear stresses at exactly 10^{-4} cm/s, erosion rates are generally measured above and below 10^{-4} cm/s at shear stresses which differ by a factor of two. The critical shear stress is then linearly interpolated to an erosion rate of 10^{-4} cm/s. Critical shear stresses will be measured as a function of depth for both the field and the laboratory sediment cores.

Description of Consolidation Studies

Wet sediments obtained from various field sites will be mixed separately into homogeneous mixtures. These well-mixed sediments will be poured into several 20 cm cores and then allowed to consolidate for time periods up to 60 days. All bulk properties for each sediment mixture will remain constant except for bulk density. Bulk density as a function of depth will be measured periodically during the test and some cores will be sacrificed and tested in the Sedflume for erosion rates. This method gives erosion rates as a function of bulk density for each sediment mixture.

Measurements of Sediment Bulk Properties

Particle size and bulk density measurements will be conducted using standard laboratory analysis. These will be detailed in later documents.

Quality Control Requirements

Although great care will always be taken, quality control will be performed routinely during sampling and measuring.

Sediment erosion rates are related to shear stresses that are applied at particular flow rates in the channel of the Sedflume. The initial flow rate used will be that which sediment erosion is observed to begin. The flow rates, as measured by the flow meter, will be checked daily by directly measuring the volume of water collected over time at the outlet of the channel. If the flow rates are not correct, the paddle wheel of the flow meter will be cleaned and inspected. If this does not correct the problem, a new flow meter will be installed.

All instruments used for bulk density analysis will be tested with standards before and after each testing period.

Particle size measurements will be run in duplicate to check for accuracy. Also, known standards will be measured before and after each testing period.

Instrument/Equipment Testing, Inspection and Maintenance Requirements

The Sedflume flow rates and all instrumentation will be tested daily before each test run. The particle size measurements will be tested against known standards.

Sedflume is designed as a field device and as such is a fairly robust system. Spare parts for Sedflume and for the coring operation are either available at any hardware store, or may be made by any competent machine shop.

Instrument Calibration and Frequency

No instruments used in the Sedflume study require calibration. All instruments will be tested as described previously.

References

Jepsen, R., J. McNeil, and W. Lick, 1999. Effects of Gas Generation on the Density and Erosion of Sediments from the Grand River, Report, Department of Mechanical and Environmental Engineering, University of California, Santa Barbara, CA 93106.

Jepsen, R., J. Roberts, and W. Lick, 1997, Effects of Bulk Density on Sediment Erosion Rates, Water, Air, and Soil Polution,Vol. 99, pp. 21-31.

McNeil, J., C. Taylor, and W. Lick, 1996, Measurements of Erosion of Undisturbed Bottom Sediments with Depth, J. Hydraulic Engineering, 122(6) pp. 316-324.

Roberts, J., R. Jepsen, and W. Lick, 1998, Effects of Particle Size and Bulk Density on the Erosion of Quartz Particles, J. Hydraulic Engineering, 124(12) pp. 1261-1267.

Taylor, C. and W. Lick, 1996, Erosion Properties of Great Lakes Sediments, UCSB Report.

Appendix A – Sample Core Logs and Laboratory Data Sheets

SEDFLUME SAMPLING DATA SHEET

Sea Engineering, Inc.
Project Number: **Project Title**:

DATE (mm/dd/yy) ____________ INITIALS ________ AREA-STATION ID ______________

ON STATION (time) ______________ WATER DEPTH _________ Ft M Fm

STATION POSITION (NAD 83) Latitude or Northing ____________________ Longitude or Easting ____________________

SAMPLER USED (circle one) Vibracorer Gravity Corer Push Corer (size ______) Van Veen Grab Other:

Sampling Area	Sample Type	Minimum Acceptable Recovery
	Sedflume*	30 cm (1 ft)
* Core must have undisturbed surface and no visible fractures in core.		

Attempt Number					
Attempt Start/End Time	/	/	/	/	/
Apparent Penetration Depth (ft or cm)					
Recovery (ft or cm)					
Accepted (yes/no)					
Rejection Code					

Rejection Codes

OP	Overpenetrated	DB	Debris interference	NS	No sediment in sampler
NR	Insufficient Recovery	DS	Disturbed surface	FR	Core has visible fracture in sediments

For Acceptable Sample:	Attach Unique Sample ID here
Visible color change near surface? No Yes at ______cm Photographed ? No Yes	

Comments

Reviewed by ____________________ Date __________

SEDFLUME LABORATORY DATASHEET

Sample Designation:

Date/Time:

Core Height: cm

Reference Height for the top of the core: cm

Reference Contact:

Location:

Project:

Item Number	Shear Stress (dynes/cm^2)	Starting Height (mm)	Ending Height (mm)	Time (sec)	NOTES

Bulk Density Datasheet

Sample Designation:

Date/Time:

Core Height: cm

Location:

Reference Contact:

Project:

Bulk Density Sample			
Depth	Tray Weight (g)	Wet Wt. (g)	Dry Wt. (g)

Particle Size Sample			
Tray Weight (g)	Dry Weight (g)	Beaker Weight (g)	Dry + Beaker (g)

Appendix A – Sample Core Logs and Laboratory Data Sheets

SEDFLUME SAMPLING DATA SHEET

Sea Engineering, Inc.
Project Number: **Project Title:**

DATE (mm/dd/yy) ____________ INITIALS ________ AREA-STATION ID ______________

ON STATION (time) ____________ WATER DEPTH ________ Ft M Fm

STATION POSITION (NAD 83) Latitude or Northing ____________________ Longitude or Easting ____________________

SAMPLER USED (circle one) Vibracorer Gravity Corer Push Corer (size _______) Van Veen Grab Other:

Sampling Area	Sample Type	Minimum Acceptable Recovery
	Sedflume*	30 cm (1 ft)
* Core must have undisturbed surface and no visible fractures in core.		

Attempt Number					
Attempt Start/End Time	/	/	/	/	/
Apparent Penetration Depth (ft or cm)					
Recovery (ft or cm)					
Accepted (yes/no)					
Rejection Code					

Rejection Codes

OP	Overpenetrated	DB	Debris interference	NS	No sediment in sampler
NR	Insufficient Recovery	DS	Disturbed surface	FR	Core has visible fracture in sediments

For Acceptable Sample: Visible color change near surface? No Yes at _______cm Photographed ? No Yes	Attach Unique Sample ID here

Comments

Reviewed by ______________________ Date ___________

SEDFLUME LABORATORY DATASHEET

Sample Designation:

Date/Time:

Core Height: cm

Reference Height for the top of the core: cm

Reference Contact:

Location:

Project:

Item Number	Shear Stress (dynes/cm^2)	Starting Height (mm)	Ending Height (mm)	Time (sec)	NOTES

Bulk Density Datasheet

Sample Designation:

Date/Time:

Core Height: cm

Location:

Reference Contact:

Project:

Bulk Density Sample			
Depth	Tray Weight (g)	Wet Wt. (g)	Dry Wt. (g)

Particle Size Sample			
Tray Weight (g)	Dry Weight (g)	Beaker Weight (g)	Dry + Beaker (g)

APPENDIX B
DATASHEET FOR TELEDYNE WORKHORSE ADCP

Workhorse Sentinel

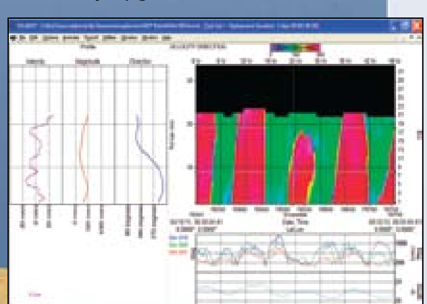
SELF-CONTAINED 1200, 600, 300 kHz ADCP

The Global Leader in High-accuracy Data Collection

The self-contained **Sentinel** is Teledyne RD Instruments' most popular and versatile Acoustic Doppler Current Profiler (ADCP) configuration, boasting thousands of units in operation in over 50 countries around the world.

By providing profiling ranges from 1 to 165m, the high-frequency Sentinel ADCP is ideally suited for a wide variety of applications. Thanks to Teledyne RDI's patented Broadband signal processing, the Sentinel also offers unbeatable precision, with unmatched low power consumption, allowing you to collect more data over an extended period.

The lightweight and adaptable Sentinel is easily deployed on buoys, boats, or mounted on the seafloor. Real-time data can be transmitted to shore via a cable link or acoustic modem, or data can be stored internally for short or long-term deployments. The Sentinel is easily upgraded to include pressure, bottom tracking, and/or directional wave measurement—for the ultimate data collection solution.



The Workhorse Sentinel offers:

- **Versatility:** *Direct reading or self contained, moored or moving, the Sentinel provides precision current profiling data when and where you need it most.*
- **A solid upgrade path:** *The Sentinel has been designed to grow with your needs. Easy upgrades include pressure, bottom tracking, and directional wave measurement.*
- **Precision data:** *Teledyne RDI's patented BroadBand signal processing delivers very low-noise data, resulting in unparalleled data resolution and minimal power consumption.*
- **A four-beam solution:** *Teledyne RDI's patented 4-beam design improves data reliability by providing a redundant data source in the case of a blocked or damaged beam; improves data quality by delivering an independent measure known as error velocity; and improves data accuracy by reducing variance in your data.*

TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Sentinel

SELF-CONTAINED 1200, 600, 300 kHz ADCP

Technical Specifications

Water Profiling						
Depth	*Typical Range[2] 12m*		*Typical Range[2] 50m*		*Typical Range[2] 110m*	
Cell Size[1]	**1200kHz**		**600kHz**		**300kHz**	
Vertical Resolution (m)	Range[3] (m)	Std. Dev.[4] (cm/s)	Range[3] (m)	Std. Dev.[4] (cm/s)	Range[3] (m)	Std. Dev.[4] (cm/s)
0.25m	*11–14*	*12.9*				
0.5m	*13–16*	*6.1*	*39*	*12.9*	*see note [1]*	
1m	*14–18*	*3.0*	*43*	*6.1*	*92–71*	*12.8*
2m	*15–20[2]*	*2.0*	*47*	*3.0*	*102–78*	*6.1*
4m	*see note [1]*		*52[2]*	*2.0*	*113–86*	*3.0*
8m					*126–95[2]*	*2.0*

[1] User's choice of depth cell size is not limited to the typical values specified.
[2] Longer ranges available.
[3] Profiling range based on temperature values at 5°C and 20°C, salinity = 35ppt.
[4] BroadBand mode single-ping standard deviation (Std. Dev.).

Long Range Mode

	Range (m)	Depth Cell Size (m)	Std. Dev. (cm/s)
1200kHz	24	2	3.8
600kHz	70	4	4.2
300kHz	165	8	4.2

Profile Parameters

Velocity accuracy:

- **1200, 600:** 0.3% of the water velocity relative to the ADCP ±0.3cm/s
- **300:** 0.5% of the water velocity relative to the ADCP ±0.5cm/s

Velocity resolution: 0.1cm/s
Velocity range: ±5m/s (default)
±20m/s (maximum)
Number of depth cells: 1–128
Ping rate: 2Hz (typical)

Echo Intensity Profile

Vertical resolution: Depth cell size
Dynamic range: 80dB
Precision: ±1.5dB

Transducer and Hardware

Beam angle: 20°
Configuration: 4-beam, convex
Internal memory: Two PCMCIA card slots; one memory card included
Communications: Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200-115,200 baud.

Standard Sensors

Temperature (mounted on transducer):
Range: -5° to 45°C
Precision: ±0.4°C
Resolution: 0.01°

Tilt: Range: ±15°
Accuracy: ±0.5°
Precision: ±0.5°
Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature):
Accuracy: ±2° [5]
Precision: ±0.5° [5]
Resolution: 0.01°
Maximum tilt: ±15°

[5] <±1.0° is commonly achieved after calibration

Power

External DC input: 20–50VDC
Internal battery voltage: 42VDC new; 28VDC depleted
Battery capacity: @0°C: 450 watt hours

Environmental

Standard depth rating:
200m; optional to 6000m
Operating temperature: -5° to 45°C
Storage temperature*: -30° to 60°C
Weight in air: 13.0kg
Weight in water: 4.5kg
* *Without batteries*

Software

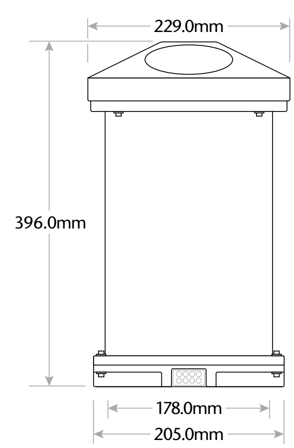
Teledyne RDI's Windows™-based software included:

- WinSC—Data Acquisition
- WinADCP—Data Display and Export

Available Options

- Memory: 2 PCMCIA slots, total 4GB
- Pressure sensor
- External battery case
- High-resolution water-profiling modes
- Bottom tracking
- AC/DC power converter, 48VDC output
- Pressure cases for depths up to 6000m
- Directional Wave Array

Dimensions



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Free online product training   **Free 24/7 emergency support**

APPENDIX C
EPA COMMENTS AND RESPONSES

Comment No.	Section	Page	Line	Comment	Response to Comment-Proposed Revision
EPA-1				Explain how a grid of 15 to 30 m is appropriate to catch differences seen at transition areas (e.g., shorelines).	The level of grid resolution (i.e., size and number of grid cells) chosen for any modeling study requires a balance between adequately simulating hydrodynamic, sediment transport and chemical fate and transport processes and the ability to conduct multi-year simulations (e.g., 20-year simulations) within a practical length of time. The proposed level of grid resolution (i.e., 15 to 30 m) is based on a combination of preliminary model testing using this grid resolution and previous experience in conducting similar modeling studies at over 40 sites. Based on preliminary model testing and professional judgment, the proposed level of grid resolution is adequate to meet the objectives of the modeling study. The resolution may be revised, however, if the results indicate that the model is not capturing large gradients that may occur in transitional areas.
EPA-2	4.1, 4.2, 4.3, 5.3.1			List and describe types of high flow, storm event, flood event, and hurricane event data needed and where it will be obtained.	The hydrodynamic model requires two types of boundary condition data to simulate high-flow (flood) events and hurricanes: 1) freshwater inflow from San Jacinto River (upstream boundary of model); and 2) water surface elevation (downstream boundary of model). The freshwater inflow during floods will be specified using flow rate data obtained from the Coastal Water Authority discharge station at Lake Houston dam and USGS gauging stations on the San Jacinto River. Water surface elevation during a hurricane will be specified using data obtained at the NOAA tidal gauging station at Battleship Texas State Park.
EPA-3				The chemical fate and transport model (QEAFATE) description alludes to covering colloidal interactions but did not discuss bioturbation in detail, this exchange mechanism is very important (see Lampert and Reible, 2009 capping model). The K-saponite represents a type of clay mineral surface that one would expect to find in these sediments. The moderate affinity of PCDDs and PCDFs for these types of clay minerals may represent a problem associated with colloid assisted transport of suspended clay particles carrying PCDDs and PCDFs offsite.	The chemical fate and transport model does simulate the effects of bioturbation, as discussed on p. 9 and 10 of the modeling study addendum. QEAFATE uses a bed model that has multiple layers, with the number of layers and thickness of the layers specified as a model input. Particle mixing within the bed due to bioturbation is simulated in the bed model by specifying the rate of mixing between the layers and the depth of mixing. Both the mixing rates and depth are specified as model inputs. The depth of mixing will be determined through analysis of vertical profiles of chemical concentrations and radioisotope activity form sediment cores collected within the Study Area. The rate of mixing between the layers will be adjusted during model calibration. The model does not specify clay mineral types, such as K-saponite, however, it does include consideration of clay sized particles and their interaction with the water column. The model simulates temporal and spatial changes in the composition of sediment in the water column and sediment bed. In addition, the model has the capability to track the fate and transport of sediment from specific locations or sources. For any particle-associated chemical, the total chemical concentration in the water column or sediment bed is the sum of the dissolved and particulate concentrations. The relative proportions of dissolved and particulate concentrations is determined by the partition coefficient for a specific chemical, with the relative amount of the particulate component increasing as the value of the partition coefficient increases.
EPA-4				Is the Sedflume data being used to verify the SEDZLJ sediment transport model, or if not, what if the data conflicts with the model?	Sedflume core data provide information on the erosion properties of cohesive (muddy) bed sediments. These data are used to develop erosion parameters that are input to the sediment transport model. Thus, the Sedflume core data are not used to calibrate and validate the sediment transport, or evaluate the predictive capabilities of the model.
EPA-5				The approach suggests that these models can also be used to evaluate remediation alternatives, but no further description of the types of remediation were provided that would suggest the limits of such approach (i.e., removal vs. containment vs. treatment).	The modeling framework (i.e., linked hydrodynamic, sediment transport, and chemical fate and transport models) will be used as one line-of-evidence in a weight-of-evidence approach to evaluate and compare a range of remediation alternatives during the Feasibility Study (FS). The general types of remediation alternatives to be evaluated during the FS may include, but are not limited to: 1) monitored natural recovery; 2) capping (containment); 3) in situ treatment; and 4) removal. The potential limitations of the predictive capability and reliability of the modeling framework with respect to evaluating remedial alternatives cannot be determined at the present time. Any limitations of the modeling framework for its usefulness during the FS will be determined during the model study.
EPA-6				The hydrodynamic model description (EFDC) provided on page 7 does not list ground water recharge or discharge.	Interactions between groundwater and surface water will not be explicitly incorporated into the hydrodynamic model. The San Jacinto River within the Study Area is a tidal system, which makes it extremely difficult to accurately estimate the relatively small amount of groundwater recharge or discharge that interacts with the surface water. With respect to the hydrodynamics

					of the river, groundwater flow will have a negligible effect on circulation in the Study Area because of the negligible amount of groundwater flow (compared to the river discharge and tidal flow).
EPA-7				Hydrodynamic Model: Calibration for the hydrodynamic modeling includes measurements of current velocities for at least one (1) high-flow event (Section 5.3.1). A high-flow event is defined as an event with a flowrate of at least 10,000 cfs (Section 3.5.1). Per the subject report (Section 3.5.1), such an event is less than one-third the flowrate of a two-year return event. The TCEQ notes that model calibration based on flowrates from such a frequent return period may not allow significant extrapolation by the model to less frequent return periods.	A similar approach has been successfully used during modeling studies at other contaminated sediment sites. See the response to comment EPA-42 for additional discussion of this issue.
EPA-8	5.4.1			Sediment Transport Model: Section 5.4.1 states that a total of 68 surface samples will be taken for the Bed Property Study. However, Figure 4 shows the locations of the surface samples, in which there are more than 68 locations. From these data, it is unclear how many surface samples will be collected and where their locations may be.	Figure 4 shows the bed probing locations and not the surface sampling locations. The title of the figure will be modified accordingly. The 68 surface samples discussed in Section 5.4.1 were collected in May 2010 as part of the sediment Sampling and Analysis Plan (SAP) and those samples are not part of the bed property study to support the sediment transport modeling. For the modeling study, 30 additional samples will be collected, as described in Section 5.4.1.2. The 68 samples collected for the SAP are located within the primary Study Area (i.e., within the vicinity of the waste impoundment area). The 30 samples collected during this study are located upstream and downstream of the primary Study Area and collocated with the bed probing sites that are depicted in Figure 4.
EPA-9	5.4.1			Sediment Transport Model: Section 5.4.1 states that the impoundment surface sediment also will be sampled. However, Figure 4 shows no sediment sampling at the location of the impoundment. The TCEQ considers the determination of the erodibility of impoundment sediments to be essential to any sediment transport modeling effort.	The sampling described in Section 5.4.1 will provide data on bulk bed properties (i.e., grain size distribution, dry density). The erosion properties of cohesive sediments will be measured during the Sedflume study (see Section 5.4.2). Sediment cores will be collected from 15 locations, with the cores collected from three distinct areas: 1) in the immediate vicinity, but outside of the perimeter of the waste impoundments; 2) upstream of the waste impoundments; and 3) downstream of the waste impoundments. The impoundments will be covered to prevent erosion and stabilize the site for all options being considered in the Time Critical Removal Action (TCRA) planned to occur in 2010. Any sampling done within the impoundments prior to the TCRA for post-construction RI/FS evaluations will be irrelevant.
EPA-10	5.4.3			Sediment Transport Model: Section 5.4.3 states that the net sedimentation rates will be determined by age dating using radioisotopes. The TCEQ is concerned that samples obtained San Jacinto River Waste Pits from areas in a channel that is being actively dredged (for shipping) are not suitable for net sedimentation rate studies. Therefore, it is necessary to understand where dredging occurs in the Study Area. Additionally, it is also important to understand where dredging spoils may be deposited in the study area.	The radioisotope cores will not be collected from areas that are being actively dredged or that have been affected by dredging or are located downstream of dredging disposal locations. A thorough review of available information and data related to past and present dredging and disposal activities in the Study Area will be conducted to guide selection of the radioisotope core locations.
EPA-11				Sediment Transport Model: The possible effects of dredging in the San Jacinto River upstream of the Study Area may also affect the calibration of the sediment transport model in the most dynamic section of the channel(s). The TCEQ requests some discussion regarding how the proposed modeling will account for the additional physical complexity introduced by the effects of possible nearby dredging.	The effects of past dredging on the sediment transport model are primarily due to changes in bathymetry and geometry of the river channel and adjacent areas. Changes in bathymetry and geometry due to dredging will be incorporated into the model through the data provided by the bathymetric survey discussed in Section 5.3.2. Use of recently collected bathymetric data in the model will adequately account for the effects of dredging in the model.
EPA-12				Sediment Transport Model: Storm surge from recent major storms (e.g., Hurricanes Ike, Rita, and flood of October 1995) may also have complicated sedimentation history of this estuarine system. Such effects will further confound the model calibration process.	The inclusion of major storm events in the calibration period for the sediment transport model provides a strong test of the predictive capabilities of the model. If the model is able to be adequately calibrated during a period when major storms occurred, then the confidence in the reliability of the model will significantly increase.
EPA-13				Chemical Fate and Transport Modeling: Calibration of chemical partitioning in sediment, whether equilibrium or disequilibrium, also can be confounded by the processes described with the Sediment Transport Model. Careful selection of appropriate calibration sample locations is essential and should be justified in the context of both the Hydrodynamic Model and the Sediment Transport Model.	.As commented in the response to comment EPA-10, the calibration sample locations (i.e., radioisotope cores) will be selected ensuring that they are undisturbed based on current knowledge of dredging and disposal activities in the past.
EPA-14	2.2			Statement of the Problem - The discussion indicates that the analysis of chemical fate and transport processes in the Study Area is needed to perform the evaluation of remedial alternatives during the Feasibility Study (FS). This seems rather limited. This information could	The utility of the modeling study is not limited to evaluating remedial alternatives during the FS. As stated in Section 2.3: "The primary objectives of the chemical fate and transport analysis are: 1) develop conceptual site models (CSMs) for sediment transport and chemical fate and

				be used for other purposes (i.e., to corroborate empirical measurements of site contaminants of potential concern (COPCs) throughout the system, to support the human and ecological risk assessments, and to provide a sensitivity analysis of expected COPC movement in future significant weather events).	transport; 2) develop and apply quantitative methods (i.e., computer models) that can be used as a management tool to evaluate the effectiveness of various remedial alternatives; and 3) answer specific questions about sediment transport and chemical fate and transport processes within the Study Area." A list of specific questions to be answered by the model is provided on p. 5 and 6. These questions incorporate the issues mentioned in the comment. Further, it is important to note that, consistent with the objectives of the RI/FS, the main use for the model will be to establish a baseline flow, sediment transport, and fate and transport conditions that will be used to predict future conditions and inform management decisions regarding risk and feasibility of remediation alternatives. The study will not be focused on understanding past releases; however, the model can be used to inform and test hypotheses on processes affecting those releases.
EPA-15	2.3			Primary Objectives of Modeling Study - Among other questions, the discussion on page 6 (last bullet) states that the chemical fate and transport model will be used to assess the effects of chemical concentrations in the surface-layer of the sediment bed have on total (i.e., dissolved and particle-associated) chemical concentrations in the water column. This question should be expanded to include the surface of the waste material as well as the sediment bed. Both could release dissolved and particle-associated COPCs and the expected behavior could be different.	As presented in Figure 2, QEAFATE Is capable of predicting the transport dissolved and particulate material. In particular, the model can simulate the movement of pore water from the bed to the water column and its associated transport of dissolved COPCs. Figure 2 will be edited to reflect this model capability.
EPA-16	2.4			Contaminants of Potential Concern - Table 1 does not list PCBs as COPCs. Total PCBs are listed as secondary COPCs in the sediment SAP for human health (Table 9) and fish and wildlife (Table 11).	Table 1 will be revised to include PCBs as a secondary COPC.
EPA-17	4.3			Data Gaps and DQOs: Chemical Fate and Transport Model - The discussion on page 18 states that information regarding the "rate of temporal change of dioxin congener concentrations in the surface-layer of the sediment bed," is a data gap. The Respondents should consider that the same information does not exist for the change in concentrations in the surface-layer of the waste material.	As part of the Time Critical Removal Action (TCRA), the exposed waste will be covered with some type of stable cap in all remedial scenarios being evaluated. After the stabilization is completed, it is safe to assume that the waste will not be not exposed, making the potential fate and transport of waste impoundment derived material significantly different than the existing conditions.
EPA-18	5.4.1			Bed Property Study - The introductory text mentions that as part of the SAP, a total of 68 surface sediment samples (0 – 10 cm) will be collected for characterization of Site and impoundment surface sediment (see Table 13 from the SAP) and that these samples will be analyzed for bulk bed properties (i.e., GSD, dry density) and these data will be used to develop inputs for the sediment transport model. Looking at Figure 4, there are no probing locations indicated within the preliminary site perimeter. So as far as the question of bed cohesiveness, it is not clear where bulk sediment analyses are proposed and why. Please clarify.	See responses to comments EPA-8 and EPA-9.
EPA-19	5.4.4			Upstream Sediment Load Study - Figure 5 depicts the location of the upstream sediment load sampler. What is the basis for proposing this sample location and why is the proposal limited to one sampler?	A significant concern during the design of the upstream sediment load study was the security and protection from vandalism of the automated sampler. After a review of potential locations for the automated sampler, it was determined that the location shown on Figure 5 was the only location in the Study Area with adequate security and protection from vandalism.
EPA-20	5.4.4			Upstream Sediment Load Study - The discussion indicates that the sampler will be serviced once every three days and decisions regarding analysis of total suspended sediment (TSS) concentration will be dictated by the occurrence of rainfall events during the 3-day period. What is the basis for the 3-day window? Is this simply a reflection of the holding capacity of the sampler (with 8 composites per day)?	The holding capacity of the automated sampler is 24 bottles, which is the reason for servicing the sampler every 3 days.
EPA-21	Appendix A	Page 7		Quality Assurance Project Plan for Sedflume Testing - There is a statement on page 7 as follows: "when non-cohesive sands are obtained at a given site, the core will be reconstructed in Sedflume cores." The Respondents should explain this statement, including the reliability of the "reconstructed" core to represent ambient conditions.	As stated in Section 5.4.2, only cohesive sediment cores will be collected for this study. Thus, the statement from the QAPP regarding non-cohesive cores is not applicable to this study. The text will be revised and the discussion related to non-cohesive cores, and reconstructed cores, will be deleted.
EPA-22	Figure 1			"Houston Shipping Channel" is not the name used in text. And is not recognized by the group.	Figure 1 will be modified so that the label reads "Houston Ship Channel".
EPA-23	Figure 2			Box for hydrodynamic model does not depict/include the "salt equations" or density-driven processes mentioned on page 8 of text.	Figure 2 will be modified to include density-driven currents.

EPA-24	References List			Citations on page 32 include "University of Houston and Parsons, 2008. Total maximum daily loads for dioxins in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-02. Quarterly report No. 3. Modeling Report – Revision 2. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure." The correct date is 2006, need to edit the reference list citation.	The November 2008 document is Work Order No. 582-6-70860-18, and the citation will be corrected.
EPA-25	Section 2.2			"…analyze the fate and transport of particle-associated chemicals within the Site and Study Area…". Study should not be limited to particle-associated chemicals. There needs to be some attention paid to dissolved transport, especially with regard to containment/remediation and the possible need for geosorbents. Granted, some apparently dissolved transport is likely to be on colloidal particles that pass through filters, but the issue remains that dissolved or colloidal transport might escape from containment adequate for sediment.	The term "particle-associated chemical" does not mean that the chemical is totally adsorbed to sediment particles. For any particle-associated chemical, the total chemical concentration in the water column or sediment bed is the sum of the dissolved and particulate concentrations. The relative proportions of dissolved and particulate concentrations is determined by the partition coefficient for a specific chemical, with the relative amount of the particulate component increasing as the value of the partition coefficient increases. The chemical fate and transport model will be used to predict the transport of both dissolved and particulate concentrations. This is indicated by the questions to be addressed by the study, see the final bullet on page 6.
EPA-26	Section 3.1			"…sediment bed composition (i.e., relative amounts of clay, silt, and sand from different sources);…". Will sediment model track size classes separately, following each particle from point of origin, as this sentence seems to imply? Or does model track median particle size and statistically estimate size class distribution (which would not link back to "different sources")? How are "different sources" of particles tracked by model?	The sediment transport model will simulate the erosion, deposition and transport of four size classes: 1) clay/silt (< 62 μm); 2) fine sand (62-250 μm); 3) medium/coarse sand (250-2,000 μm); and 4) gravel (>2,000 μm). The model simulates temporal and spatial changes in the composition of sediment in the water column and sediment bed. In addition, the model has the capability to track the fate and transport of sediment from specific locations or sources. The technical memo will be edited to incorporate more details on the sediment class definition.
EPA-27	Section 3.1			Will particulate organic carbon (POC), total organic carbon (TOC), and/or dissolved organic carbon (DOC) be in the sediment and chemical models? Mention of partitioning implies yes, but not clearly stated. Whether or not explicitly mentioned in this plan, future review of work should assure that these organic parameters are included.	The model will not explicitly simulate transport and fate of organic carbon (i.e., POC, DOC). The effects of organic carbon on partitioning are incorporated into the model through the use of user-specified POC content in the water column and sediment bed.
EPA-28	Section 3.1			"The sediment transport model predicts the transport and fate of inorganic sediment; the transport and fate of organic solids is not simulated by the model.". Then the "dissolved" fraction in the chemical fate model must simulate/include any organic solid transport of COPCs, whether dissolved, colloidal, or particulate	The chemical fate and transport model simulates the transport of total chemical concentration; the transport of dissolved and particulate chemical concentrations are not explicitly simulated by the model. The model predicts temporal and spatial changes in total chemical concentration in the water column and sediment bed. Given the predicted value of total chemical concentration at a particular location, the dissolved and particulate concentrations are calculated using standard partitioning equations.
EPA-29	Section 3.2.1			Hydrodynamic modeling: It is not clear where the lower boundaries of the hydrodynamic model are proposed to be. Figures imply somewhere in vicinity of Lynchburg Ferry, and Table 2 refers to the tide gauge at Battleship Texas. Section 4 implies the Battleship gauge will provide "water surface elevation and salinity at the downstream boundary." There needs to be two boundaries at that area, one for the interface with the Buffalo Bayou branch (i.e. the main ship channel, segments 1006, 1007), and one for the interface with the lower San Jacinto River/HSC reach from Lynchburg to Galveston Bay (segment 1005, plus other "side bays"). Sea tides come up from Galveston Bay, and from the Lynchburg intersection can propagate both up the San Jacinto River and up the main channel (Buffalo Bayou branch). The Buffalo Bayou branch is really more like a "side stream boundary", it is not "downstream" from tidal perspective. Downstream river flow from the San Jacinto River ("north") can go both down channel toward Galveston Bay ("south") and up Buffalo Bayou ("west"), depending on how tide and flow interact at the 3-point Lynchburg intersection. Sediment also may be transported west, south, or north from there. The model should not combine west and south boundaries, or it could be misleading with regard to where water and transported load goes to or comes from. The water body or area called Old River is another complex detail. It provides a circular loop back to the San Jacinto channel adjacent to the 3-way intersection. Old River is clearly meant to be within the model domain (Figures 3 and 4), as it should be, but it cannot represent the main channel reach along Buffalo Bayou.	It is envisioned that the downstream boundaries of the hydrodynamic model will be located at the southern extents of the main (eastern) channel of the San Jacinto River and the Old River channel. Preliminary model testing has demonstrated that specifying the downstream tidal boundary at these two locations produces realistic tidal circulation within the Study Area. However, it will be analyzed the possibility to modify the downstream boundaries, so that the model can provide separately the flow going to the west and to the south in the Houston Ship Channel. See response to comment EPA-54.
EPA-30	Section 4.1 Table 2			Because of lower boundary issues mentioned above, the hydrodynamic model could consider using the Morgan's Point tide gauge to represent the "south" boundary. Or, could develop some way to represent both lower boundaries based on the Battleship gauge. The Battleship tide gauge is near the "west" boundary in Buffalo Bayou.	If the water surface elevation data from the NOAA gauging station at Battleship Texas State Park does not produce adequate calibration results, then other tidal data sources will be considered and evaluated.

EPA-31	Section 4.2			"High-flow events are the focus of a sediment load study because, typically, a majority of the annual load occurs during a small number of high-flow events.". This study should focus on the redistribution of "old" sediment already in the system, at least as much as on the annual load of "new" sediment entering the system. Other comments below address that the proposed "high-flow event" of 10,000 cfs for sampling purposes is not very high for the site. A 10,000 cfs flow in the SJR may not be a major annual loading event. Not clear if the statement on page 16 is about model simulation of larger events (>>10,000 cfs).	The statement referred to in this comment addresses the issue of external sediment loading from the San Jacinto River to the Study Area. The "sediment load study" means the field study to collect data that can be used to estimate the annual load of sediment from the river to the Study Area; it is not referring to the sediment transport modeling study, which will evaluate the transport and fate of sediment within the Study Area.
EPA-32	Section 4.2			"bed elevation change" is mentioned as information needed. Not clear if that is to include changes due to subsidence, past or present or future, as well as due to sediment dynamics. This draft does not say how long the model simulation periods will be (a few months? A few years? A few decades?), for either calibration or predictive simulations of future conditions.	In the context of this type of modeling, "bed elevation change" refers to changes due to sediment dynamics, and does not include changes due to subsidence, which has essentially ceased in the study area based on Harris County Subsidence District data and observations. The calibration period will be determined after the field studies are completed and the sediment transport data area analyzed. The length of predictive simulations for the FS will be determined after the model calibration is completed. However, it is likely that multi-decadal simulations (e.g., 20 years) will be used for the FS evaluations. The technical memo will be edited to include a clarification regarding the proposed long-term predictive simulation runs.
EPA-33	Appendix A			"It can be seen in this plot that the surficial sediments erode easily at lower sediments, but at lower levels in the core the sediments are much more difficult to erode requiring much larger shear stresses.". First part of sentence does not make sense. Perhaps the highlighted word "sediments" was not the intended word…may have meant to say "shear stresses" or similar?	The sentence in Appendix A will be revised to state: "It can be seen in this plot that the surficial sediments erode easily at lower shear stresses, …"
EPA-34	Appendix A			"…and average bulk properties will be plotted with binned depth.". Perhaps this refers to statistical "bins" for categorizing data, but it is not clear.	The erosion rate tests are conducted using cycles of shear stress (i.e., increasing from low to high applied shear stress) over a specified depth interval in the core, which is typically about 5 cm in thickness. The "binned depth" refers to a depth interval for a particular shear stress cycle. The text in Appendix A will be revised as needed to clarify this issue.
EPA-35	Appendix A			Appendix A: "Quality assurance objectives and results will be assuaged in the process of preparing the report.". Is 'assuaged' the intended word?	This sentence in Appendix A will be revised to state: "Quality assurance objectives and results will be assessed ….''
EPA-36	Appendix A			"…6 cores represents approximately on week in the field." Replace 'on' with 'one'.	The text in Appendix A will be revised as requested.
EPA-37	Appendix A			"Coring locations will be chosen with the following tenants in mind:…". Replace 'tenants' with 'tenets'.	The text in Appendix A will be revised as requested.
EPA-38	Appendix A			"…knowledge of sediment variability both aerially and with water depth…". Replace 'aerially' with 'spatially'.	The text in Appendix A will be revised as requested.
EPA-39	Section 4.3			"…(Univ. of Houston and Parsons 2008)." That needs to be 2006 instead of 2008.	See response to comment EPA-24.
EPA-40	Section 4.3			Interpretation of radioisotope data from sediment cores to establish the age of sediment or rates of change seems to be a very subjective process. There will be a lot of uncertainty associated with net sedimentation rates and temporal change in dioxin/furan concentrations derived from such analyses, especially in relatively shallow and dynamic situations like the San Jacinto delta.	The analysis of the radioisotope core data will use well established procedures, which are objective, that have been applied to numerous cores at a large number of contaminated sediment sites. These procedures will also provide quantitative estimates of uncertainty in the net sedimentation rates derived from the age-dating analysis of the cores.
EPA-41	Section 5.3.1			"The mean flow rate in the San Jacinto River is 2,200 cfs, and high-flow events with return periods of 2, 10, and 100 years correspond to flow rates of 31,600, 107,000 and 329,000 cfs, respectively.". Cite the source of, or provide the basis for, these flow statistics.	A Log Pearson Type 3 flood frequency analysis of historical flow rate data collected at USGS gauging stations on the San Jacinto River were used to determine these flow statistics. The period of record for the flow rate data was 1985-2009.
EPA-42	Section 5.3.1			Plan proposes 10,000 cfs as defining a high-flow event for hydrodynamic monitoring purposes. Since the study plan anticipates two high-flow events during a month or so, and since the cited 2-yr event (31,600 cfs) is significantly larger than 10,000 cfs, the proposed high-flow events might be considered "slightly-higher-than-normal-flow events" in the scheme of river dynamics. Modeling should be able to simulate truly large high-flow events.	Collecting hydrodynamic and sediment transport data during high-flow events at a contaminated sediment site is always uncertain because of the relatively low probability of a high-flow event occurring during a specific time period. Constraints on the RI/FS schedule means that the modeling study needs to be completed within a specific time period. Thus, a limited period of time is available to collect field data and, typically, a rare high-flow event (e.g., 10-year flood) will not occur during this time period. Thus, data collected during elevated high-flow events (i.e., greater than 10,000 cfs for this study) are used as best as possible for model calibration and validation. This approach has been used successfully at other contaminated

					sediment sites where the calibrated model was used for 100-yr flood event providing reliable results.
EPA-43	Section 5.3.1			"In the region upstream of the primary Study Area, a total of 15 cross-channel transects will be surveyed. In the region downstream of the primary Study Area, a total of 12 cross-channel transects will be surveyed as shown in Figure 3.". Transects marked on Figure 3 cross only the deep channel in upstream reach – how will bathymetry of the wide shallow areas be determined? Water and sediment move there also. There should be a lot of 3-ft by 3-ft grids in the model to cover the shallow water area.	Bathymetry data from NOAA nautical charts are available in the wide shallow areas. These data are adequate for specifying model inputs in those areas.
EPA-44	Section 5.3.1			Transects downstream from Site: much of Old River is often covered by parked barges, getting the transect data may be more difficult than expected.	The field study crew will endeavor to overcome potential obstacles and collect as much data as possible. Changes to proposed sample locations that may be required as a result of obstacles encountered during sampling will be discussed with EPA during the field sampling event.
EPA-45	Section 5.3.1			Model lower boundary, vicinity of Lynchburg Ferry/De Zavalla Point: since the model needs two lower boundaries to separately characterize the "south" and "west" branches of channel (see Comment #29) some bathymetry to characterize those boundaries is needed.	Bathymetry transects are located in the immediate vicinity of the two downstream boundaries, see Figure 3.
EPA-46	Section 5.4.1.1			Sediment probing in Old River may be obstructed by parked barges. May need to define a procedure to use in case the "pre-programmed target coordinates" are under a group of barges. Also, not clear how the 6-inch interval markings on probe are read. Bottom will not be visible at most sites, so unlikely to read marks at sediment surface; water surface could index to markings, but not clear if depth to bottom will be consistent around a sample location.	The field study crew will endeavor to overcome potential obstacles and collect as much data as possible. The water surface will be used to index the markings.
EPA-47	Section 5.4.2			"The locations of these cores will be determined upon completion of the sediment bed probing study (see Section 5.4.1.1) and areas of cohesive bed sediments have been identified.". Does this indicate that non-cohesive bed sediments will not be included in the Sedflume study? Appendix A indicates that non-cohesive materials can be Sedflume tested.	Only cohesive bed sediments will be included in the Sedflume study. The text will be revised and the reference to testing of non-cohesive cores will be deleted.
EPA-48	Section 5.4.3			"(^{137}C)" needs 's' inserted after 'C' to represent cesium instead of carbon. Also, what if the anticipated cesium peak occurs within sub-sample interval that is not selected for analysis, e.g. 8 to 12 cm interval? What if true cesium peak has eroded away, leaving an apparent peak that does not correspond to assumed 1963 date of peak? How could analyst tell the difference between these two possible situations?	The text will be revised as requested. If needed, the archived sub-samples can be submitted for laboratory analysis and the additional data would be used to refine the age-dating analysis, as described at the end of Section 5.4.3. in addition, the analysis of the ^{137}Cs activity profile is not done in isolation. This analysis is done in conjunction with the analysis of the ^{210}Pb activity profile, as well as physical information for the core, resulting in several lines of evidence that are used to characterize deposition rates.
EPA-49	Section 5.4.3			"Sub-samples will be submitted for laboratory analysis of ^{137}C and ^{210}Pb activity from every eighth sub-sample interval, starting with the 0 to 4 cm interval.". Sounds like second selected sub-sample would be from 32 to 36 cm interval. Is that correct interpretation? Seems like peaks might fall within untested intervals. Also, need to add 's' after 'C' to indicate cesium instead of carbon.	The second sub-sample will be from the 32-36 cm interval. If needed, the archived sub-samples can be submitted for laboratory analysis and the additional data would be used to refine the age-dating analysis.
EPA-50	Section 5.5			Dioxin profiles in sediment may indicate an erratic "rate of temporal change," with increases and decreases in quick succession (as seen in profiles from nearby). Not clear how a synthetic average net rate of change would be used.	Temporal changes in dioxin concentrations will be used both qualitatively and quantitatively to evaluate the predictive capability of the chemical fate and transport model.
EPA-51	Section 2.1	Page 3		Site History states at the end of the first paragraph: "For the purposes of the modeling study, the Study Area is defined as the San Jacinto River from Lake Houston to the Houston Ship Channel (Figure 1)." It is highly probable that transport of chemicals of potential concern (COPCs) from the Site are beyond the intersection with the Houston Ship Channel, thus the Study Area should be extended farther downstream to the entrance of the Houston Ship Channel into Galveston Bay. We understand that other sources of COPCs are likely and thus monitoring and design of the study should take this into consideration while accurately assessing the extent of COPCs fate and transport downstream.	Currently, we believe that the spatial extent of the modeling domain is adequate for meeting the objectives of the study and answering the questions listed on p. 5 and 6. If the results of the modeling study indicate that the spatial extent of the modeling needs to be expanded, then it will be possible to do so in the future.
EPA-52	Section 2.1	Page 4		Site History makes reference in the final paragraph to "late successional stage estuarine riparian vegetation." During a Site visit, the Site seemed dominated by hackberry trees which are often considered pioneer or early successional stage trees in this portion of Texas. The basis for the characterization of the Site as having vegetation characteristic of a late successional stage should be validated to verify this description.	This sentence in Section 2.1 will revised as follows: "The impoundments are currently occupied by estuarine riparian vegetation to the west of the central berm …"
EPA-53	Section 3.1	Page 9		Description of Modeling Framework. Will any of the system of models account for movement in	The effects of boat movement on sediment transport will not be explicitly incorporated into the

				the water column and sediments due to boat turbulence?	modeling analysis. Water column measurements and predictions will implicitly include the collective effects of propeller wash, but this kind of model can't include the short term impact of propellers. Propeller wash models exist and are used to evaluate the potential scouring effects of vessels mostly for engineering design of alternatives during the feasibility study. The need for a propeller wash model may arise during the feasibility study but it cannot be determined at this stage.
EPA-54				On comment EPA-29, the resolution states: "It is envisioned that the downstream boundaries of the hydrodynamic model will be located at the southern extents of the main (eastern) channel of the San Jacinto River and the Old River channel. Preliminary model testing has demonstrated that specifying the downstream tidal boundary at these two locations produces realistic tidal circulation within the Study Area. However, it will be analyzed the possibility to modify the downstream boundaries, so the model can provide separately the flow going to the west and to the south in the Houston Ship Channel." After consideration, the EPA team concludes that the modeling must be developed with separate downstream boundaries opening to the west and to the south. The rationale is that the hydrodynamic model should not combine west and south boundaries, as it would be misleading with regard to where water and transported load goes to or comes from. Please revise the resolution to reflect this directive.	The downstream boundaries of the model will be moved to: 1) western boundary in the Houston Ship Channel that is approximately 0.50 to 0.75 mile upstream from the mouth of the San Jacinto River; and 2) southern boundary that is about 0.25 mile southeast of the Lynchburg Ferry route. Moving the downstream boundaries of the model to these locations will improve the predictive capability of the model, with respect to water movement in the San Jacinto River and Old River channel.
EPA-55				To ensure that calibration of the hydrodynamic and chemical fate models are valid, water column samples analyzed for dioxin should be collected within the same time period as other model calibration data. Directly comparing model predictions from the calibration exercise to synoptic dissolved and suspended solids dioxin concentration measurements will better validate the partitioning, hydrodynamics, and sediment dynamics used in the modeling. Water samples for model calibration can be collected at two or more sites within the area to be simulated by the model. Suggested locations include: (1) in proximity to the pits, perhaps in the river channel near the highway bridge slightly downstream from the site; (2) somewhere upstream from the pits, near or slightly beyond the preliminary site perimeter. More than two water sampling sites may be used. Sampling points should be located in places that will correspond to model output points, to ease comparisons during calibration. Water samples should be collected several times during the period monitored for model calibration. The water sampling method used should allow detection across a wide range of possible concentrations, and allow the calibration data to be compared to previous data. The high-volume sampler method used by the TMDL project is strongly recommended.	Water column dioxin concentration data have been collected in the San Jacinto river and were used to evaluate the predictive capability of the TMDL dioxin model of the Houston Ship Channel and San Jacinto River. Those data will be used during the calibration and validation of the chemical fate and transport model in this study. With respect to collecting field dat a (i.e., dissolved and particulate dioxin concentrations in the water column) to evaluate partitioning, it is difficult and problematic to obtain reliable dioxin partitioning data due to variability and uncertainty in field data. Ranges of partition coefficients for various dioxin congeners are well established in the peer-reviewed literature, making it unnecessary to collect site-specific data prior to finalizing the chemical fate and transport model. We propose to develop and calibrate the chemical fate and transport model as discussed in the modeling work plan. The sensitivity of the model to value of the dioxin partition coefficient will be evaluated after the calibration process is completed. If the results of that sensitivity analysis indicate that additional site-specific data are needed to reduce the uncertainty in model predictions, then a field study will be designed and conducted to provide the appropriate data related to dioxin partitioning. As described in the RI/FS Work Plan, collection of surface water for chemical analyses will also be considered if there are unacceptable uncertainties associated with the use of estimated surface water quality parameters in the risk assessments. Knowledge and insights gained from the modeling study and the risk assessments will be used to design that field study, if it is needed.